OCT 26 1935

Engineering News-Record

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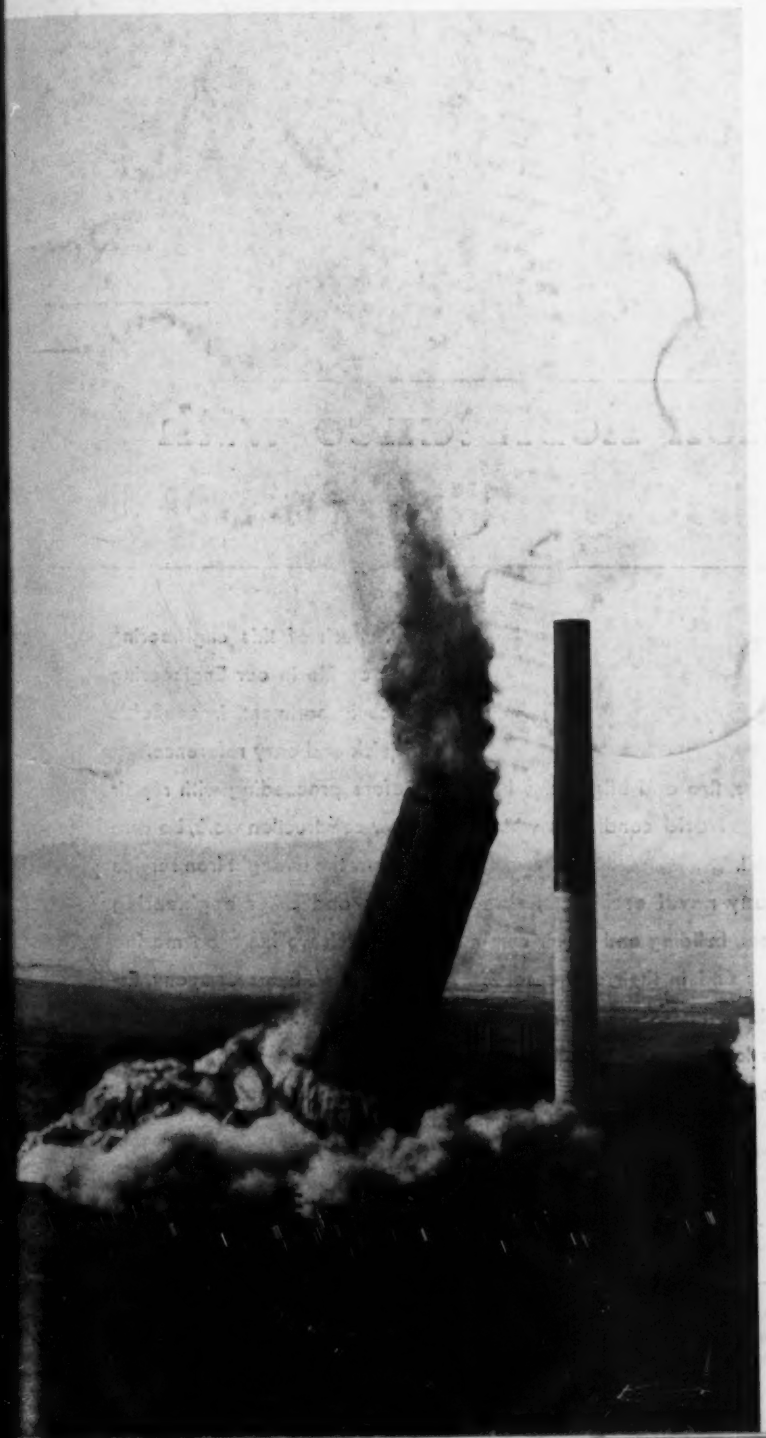

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CONVENTION REPORTS

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Municipal Officials at Cincinnati

Steel Fabricators at White Sulphur Springs

Old age aided by a charge of dynamite overtakes a smelter stack at Garfield, Utah, as its successor, rising to a height of 413 ft., goes into service

..for Corrosion Resistance with BYERS WROUGHT IRON

Hull Plates • Water Lines
Rain Leaders
Fire and Bilge
Lines

CORROSION makes short life of hulls and piping in most inland waters where some other metal has been substituted for the job wrought iron has done so well for years.

Illustrated is the new Towboat "Champion Coal" operated by the Pittsburgh Coal Company in the Monongahela River. Based on the long experience of fleet operation wrought iron was chosen for hull plating, all water lines, rain leaders, fire and bilge lines because of acid conditions which prevail.

Many naval architects, ship owners, building and repair companies find in their own records ample confirmation of wrought iron's long, satisfactory service in inland, harbor and sea-going craft. Much of this engineering proof, on file in our Engineering Service Department, is available for quick and easy reference.

Before proceeding with repair or new construction work, be sure to review the wrought iron service records and other engineering data which we have on marine service. A. M. Byers Company. Established 1864. Pittsburgh, Boston, New York, Philadelphia, Washington, Chicago, St. Louis, Houston.

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That Breathing *Spell*

THE other day this writer watched the picked riders and ropers of the national rodeo do their stuff. As he watched the boys and girls trying to stick astride their plunging steers and sunfishing broncs, he got to thinking about that breathing spell recently announced by the President. A breathing spell surely would have looked good to any one of those desperate riders at any instant between his headlong charge from the chute and that welcome blast of the timer's horn.

Just what was it that made the task of those riders so difficult? What was the essential difference between riding a bucking outlaw and sitting a well-trained cow-pony in the calf-roping event? Chiefly it was a matter of coordination between horse and rider. With the outlaw there was none. The rider was at the mercy of the horse because *he never could guess what the animal would do next.* He could neither plan nor execute anything worth while; it took all his mental and physical energy just to sit tight. But with the coordination of rider and cow-pony came sureness, confidence and well-directed effort that made for a certain thrilling efficiency with the job in hand.

EVER since the depression hit us, business has been riding an outlaw. It has been pretty roughly handled and seldom could guess what might be coming next. So, for the time being, it gave up trying to do anything but stick fast. Then government entered the arena in a big way. Some of the things it did were a help but others seemed to the rider to make matters worse. Here is no need to appraise the justice of his judgment; what counts is the effect on business initiative and enterprise; certainly a lot of business has been scared almost to death by some of the ministrations of government.

Then came the President's welcome announcement of a breathing spell. But if a breathing spell means anything it means a period of reasonable certainty and security during which we may expect conditions to remain sufficiently stable for us to look ahead and plan useful effort with some confidence. Certainly it must mean a suspension of useless controversy and of the insignificant but very irritating pin-pricking that recently has disturbed the relations between government and business.

That is why it is too bad that the Department of Labor should have seen fit to release in the October issue of its "Monthly Labor Review" a report that purports to set forth some facts about "company unions" but which, in fact, is just another partisan attack on an institution that probably will have in due course an orderly consideration by a competent tribunal. Here it is not intended to debate the significance of the findings, but it may be noted in passing that several of the questions established by the investigators as standards for judgment reveal a trace of the "have-you-stopped-beating-your-wife-yet" flavor. Certainly as criteria of the practical merit of company unions the data are quite inadequate and inconclusive.

But right here and now that is not the point. If the Department of Labor wishes to investigate, well and good; if its staff wishes to assemble and examine its data preparatory to a conclusion, well and good also. But no useful purpose is served by issuing piecemeal and prematurely such data as it may have in hand. This can justify no definite or useful conclusions and can serve only to fan a controversy that for the moment might be permitted to subside with advantage to all except the professional agitator.

IF the President wants to grant business a real breathing spell, in the course of which it may count on some measure of stability and plan ahead with confidence, he should see that every department of his administration refrains from public utterances that foster unrest without making any practical contribution toward the settlement of our problems.

Willard Chevalier

ENGINEERING NEWS-RECORD

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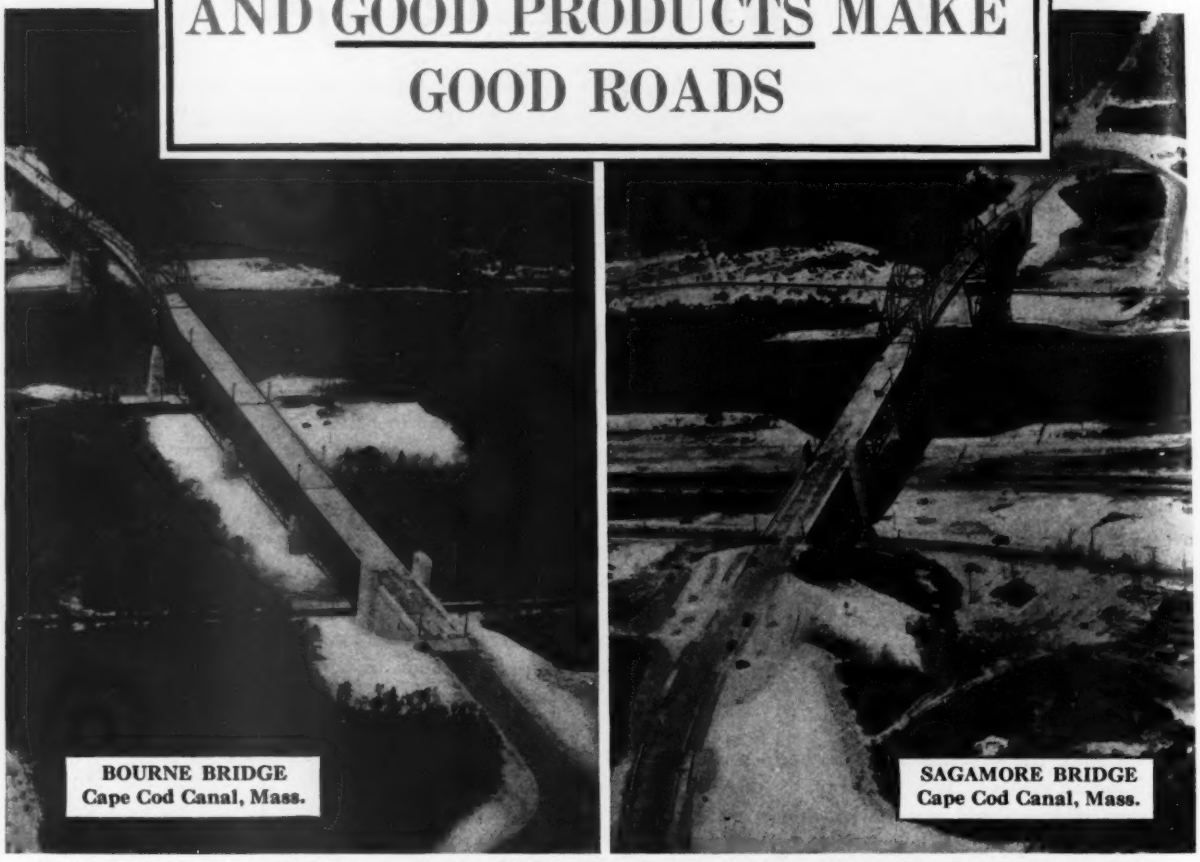

Bridge Decks—Socony Asphalt over a mop coat of Socony Waterproofing Asphalt. *Approaches*—Bituminous Macadam using Socony Binders B & C.
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In the News:

THE SERIES OF EARTHQUAKE SHOCKS which had harassed Helena, Mont., for a week reached a climax last Friday in a shake that caused building damage estimated at $2,000,000. Prior to 1925, this region was not generally regarded as earthquake territory.

BIDS FOR FOUNDATION CONSTRUCTION were invited this week on twenty of the PWA large-scale housing projects, in accordance with the policy of starting foundations while superstructure plans are still under development. New projects in Toledo and Schenectady were also added to the list, bringing the total to 46 in 33 cities.

THE PAN-AMERICAN HIGHWAY EXTENSION south from Mexico City into Central America may be said to have started with the signing of agreements with Guatemala, Honduras and Panama for them to furnish bridge foundations and the United States the superstructures. The work will be handled by the U. S. Bureau of Public Roads, with C. B. McCullough, formerly bridge engineer of Oregon, in charge.

WPA HAS ALLOTTED $6,574,000 for Orange County, Calif., flood control, covering eight earth dams and water-spreading works in the channel of the Santa Clara River.

GRADE-CROSSING PROGRAMS, after long delay, have secured formal Presidential approval, according to advices from Washington.

FHA hopes to interest private capital in large-scale housing through permission to issue insured mortgage bonds that can be offered to the public. Great care has been exercised to keep such bonds from any of the taint attached to the type of real estate mortgage bond that fared so badly in the depression.

WORK BEGAN LAST WEEK on the 6,500,000-cu.yd. earthfill dam on the Conchas River near Tucumcari, N. M. It is to be built by the Army Engineers.

NEWSPAPERS last week carried a thought-provoking story of tests at Yale of a vacuum apparatus for extracting excess water from concrete pavement, making possible "a concrete from 30 to 100 per cent stronger than that produced by present methods and one that will harden and dry in about 20 minutes."

In This Issue:

MOVING A LARGE BUILDING is always a spectacular job and one that requires considerable skill and technical knowledge. In New Orleans, where foundations conditions are not of the best, a 5,000-ton concrete building was recently moved 162 ft. over pile-supported footings in one of the notable operations of its kind in recent years. Some 600 flanged steel spools were used in place of the usual relatively long rollers.

A CONCRETE STACK 413 ft. high, built at a copper smelter in Garfield, Utah, is the tallest of its kind in the U. S. Its design and construction are described.

PUZZOLANIC MATERIALS, as blending agents in cement or as concrete admixtures, are receiving renewed attention in the effort to produce more durable concrete. The advantages and pitfalls that accompany the use of puzzolanas are analyzed by Edw. W. Scripture, director, Master Builders Research Laboratories, in an article of exceptional timeliness.

PUBLIC-WORKS OFFICIALS, as represented by the membership of the American Society of Municipal Engineers and the International Association of Public Works Officials, met in Cincinnati last week for a three-day session of discussions on municipal problems. The staff report of the meeting is published in this issue.

AT THE FALL MEETING of the American Society of Civil Engineers in Birmingham last week the defeat of the proposal to establish a grade of "fellow" in the society and a paper on malaria-mosquito control in connection with southern reservoir construction were high spots on the program.

THE SECOND PART of the article discussing the subject of "impossible" contracts is published in this issue.

PROFESSOR HARDY CROSS concludes his discussion of the limitations and application of structural analysis in another significant article.

A TWO-YEAR INVESTIGATION by a committee of the New England Water Works Association reveals large differences between predicted and actual loss in capacity of cast-iron pipe. The effect of water quality, of cement and enamel linings and some data on concrete pipes are also discussed in the report abstracted in this issue.

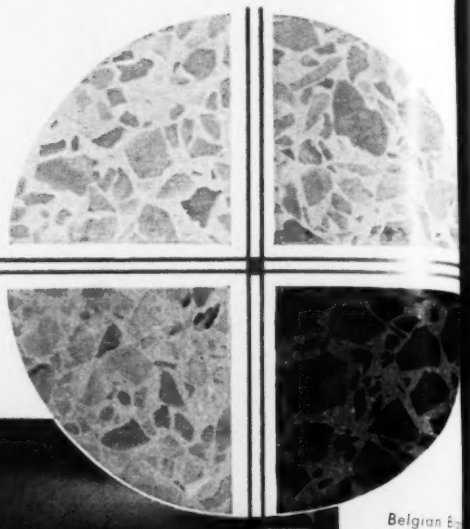
Coming Articles:

A DAM ON THE ORBA RIVER IN ITALY failed on Aug. 13. Information concerning the dam and the cause of failure has been difficult to obtain. In an article to be published soon, E. Probst, former editor of *Bauingenieur*, following a visit to the site tells of the failure and comments on the probable cause.

Fine Floors for Business

FLOORS of fine terrazzo are floors for business first of all—particularly where business receives the public as customers or prospective customers. In a public utility office, for example, such as the one shown here, that cheerfully colorful terrazzo floor is decidedly an asset. It welcomes the visitor, creates a pleasant atmosphere, yet looks crisply business-like. And it is business-like in the way it keeps its good appearance, in its economy of maintenance, and in its concrete-like durability. The details will interest you. Ask your architect, or write Universal Atlas Cement Co. *(United States Steel Corporation Subsidiary)*, 208 South La Salle Street, Chicago.

Fine terrazzo floor, photographed in full natural color, in Texas Cities Gas Company Building, Waco. Made with Atlas White portland cement. National Terrazzo & Tile Company, Houston, terrazzo contractor. T. Brooks Pearson, Waco, architect. The actual-size, true-color terrazzo samples at the right illustrate marble and pigment combinations similar to the marbles and pigments which were used for this floor.



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ATLAS WHITE PORTLAND CEMENT

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ATLAS PORTLAND CEMENT

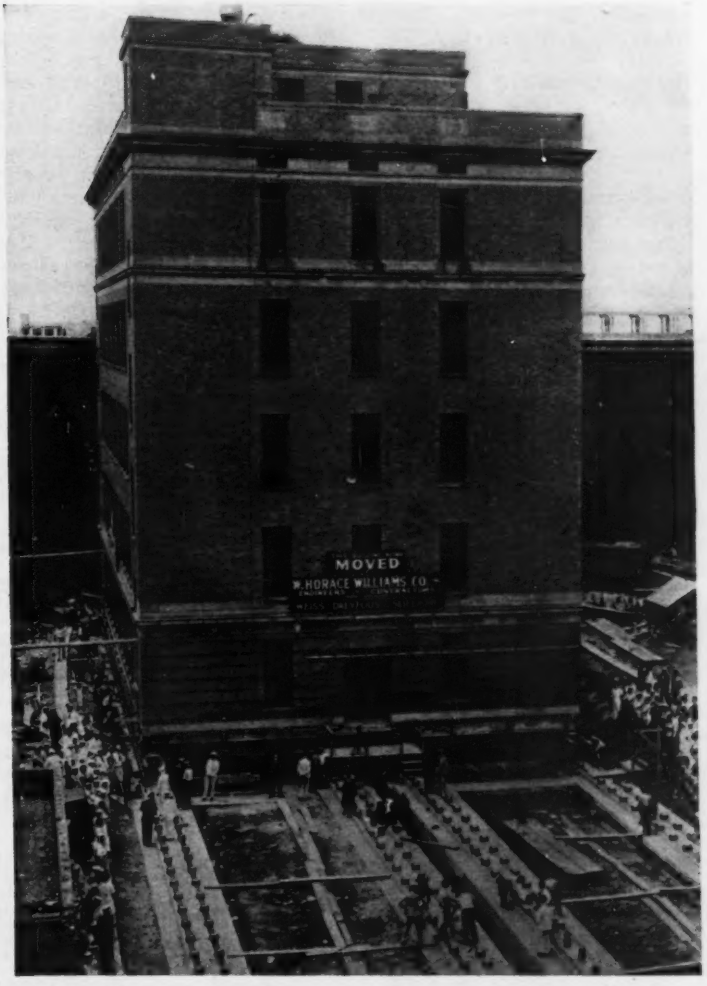
ENGINEERING NEWS-RECORD

October 24, 1935

Five-Story Building Moved on 600 Steel Spools

Reinforced - concrete structure weighing 5,000 tons shifted 160 ft. on pile-supported runway to make way for new building in Louisiana State University Medical Center, New Orleans

By C. Glenn Cappel
Vice-President, W. Horace Williams Co., Inc., New Orleans, La.



PLACING STEEL SPOOLS on runway built to carry this 5,000-ton building to a new location.

CONFRONTED with the problem of finding a site for a new 17-story dental building for its medical center at the Charity Hospital in New Orleans, officials of Louisiana State University found that the only available location was occupied by a five-story-and-basement reinforced-concrete ward building. Since the building was in good condition and the facilities it afforded were sorely needed at Charity Hospital, it was decided to move it to a new location. The firm with which the writer is associated was engaged to undertake the task.

The problem was to transfer the load onto a movable structure and to provide the proper foundation on which to move the building 162 ft. along its major axis. The building is of reinforced-concrete frame with brick spandrel walls and tile-and-joist floor construction. It is 57 ft. wide, 105 ft. long and 77 ft. high above the first floor. The columns are in four rows along the major axis, two rows in the exterior walls, and two interior rows 10 ft. on centers and centering on the building, except that one column on the front end of the building is offset 3 ft. toward the adjacent wall, and an intermediate column on the same face is placed midway between the other two columns. There are 37 columns in all, and as nearly as could be figured the moving load was about 10,000,000 lb., including the weight of the traveling structure.

Foundation conditions in New Orleans vary considerably. There is no rock or other firm structure in the subsurface, but generally at varying depths strata of mixed sand and shell are found. Although these strata are often non-uniform and uneven, test borings at the site showed a satisfactory stratum that was comparatively uniform and that could be reached with 45-ft. piles. The question of settlement under a sudden load presented a serious problem. Normally in this area, if a structure is properly designed, the settlement that almost invariably takes place is uniform, but in such cases the footing receives its load gradually. During its life of ten years

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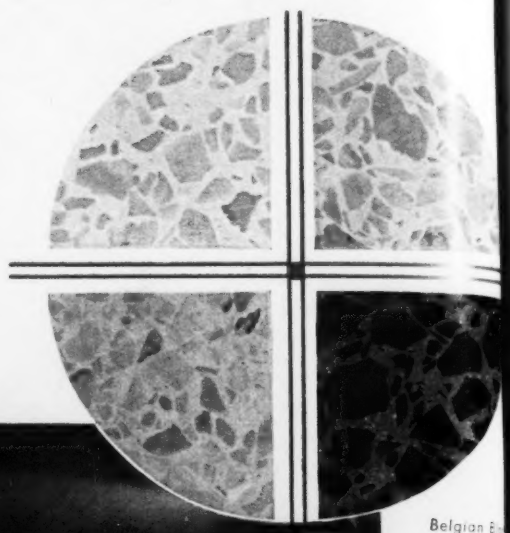

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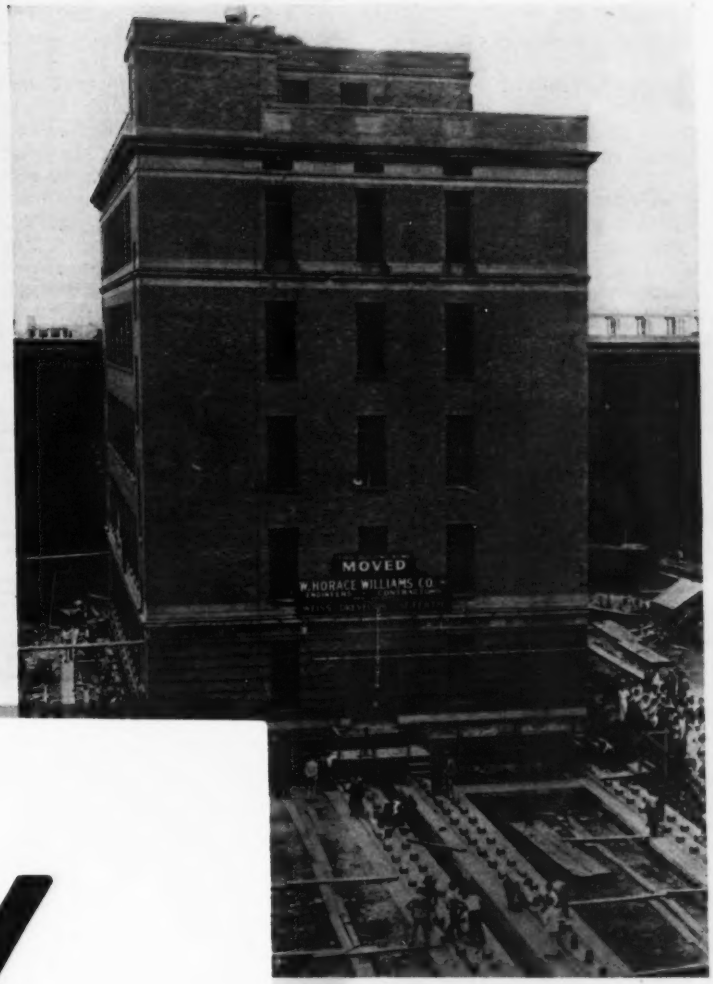

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but generally at varying depths strata of mixed sand and shell are found. Although these strata are often non-uniform and uneven, test borings at the site showed a satisfactory stratum that was comparatively uniform and that could be reached with 45-ft. piles. The question of settlement under a sudden load presented a serious problem. Normally in this area, if a structure is properly designed, the settlement that almost invariably takes place is uniform, but in such cases the footing receives its load gradually. During its life of ten years

the ward building had been satisfactorily supported on its footings which rested on piles driven to the same stratum proposed for the piles of the new foundations and the traveling runways. It was a matter of judgment rather than calculation that finally determined an addition of 15 per cent more piles under the new foundation and the runways, to provide for the effect of quick loading. After this decision it was only necessary to design continuous footings for 162 ft. in the direction of the move. These footings, of course, had to be designed for the heaviest column in each row.

Temporary building support

A steel cradle composed of two 24-in. beams was clamped to each row of columns, bolted through and grouted in after having been brought to line and grade within an accuracy of $\frac{1}{64}$ in. On top of these cradle beams two 12-in. I-beams were bolted onto the columns in the opposite direction and grouted in up to the bottom of the first floor. Next the 18-in. I-beams for the runway were set in position on short steel columns, which in turn rested on 18-in. sill beams running continuously through the basement.

The basement floor, in order to provide against hydrostatic pressure, had been poured directly on top of the footings, but it was deemed necessary to use distributing sill beams since some concentration of load might occur directly over one of the stub columns, which might rest near the edge of a footing, in which case there would have been a tendency for this footing to kick up or at least cause an overload on certain piles.

Moved on flanged steel spools

The actual running media were 6-in. spools, turned out of 7-in. shafting, to provide a $\frac{1}{2}$-in. flange on each end. These flanges were beveled $\frac{1}{8}$ in. in a half inch. The turn surface of the spool was $7\frac{1}{8}$-in. long, the flange of the cradle beams was 7 in. wide and of the traveling beam 6 in. wide. There were 342 spools under the building at one time, and a total of 600 were used, each weighing about 100 lb.

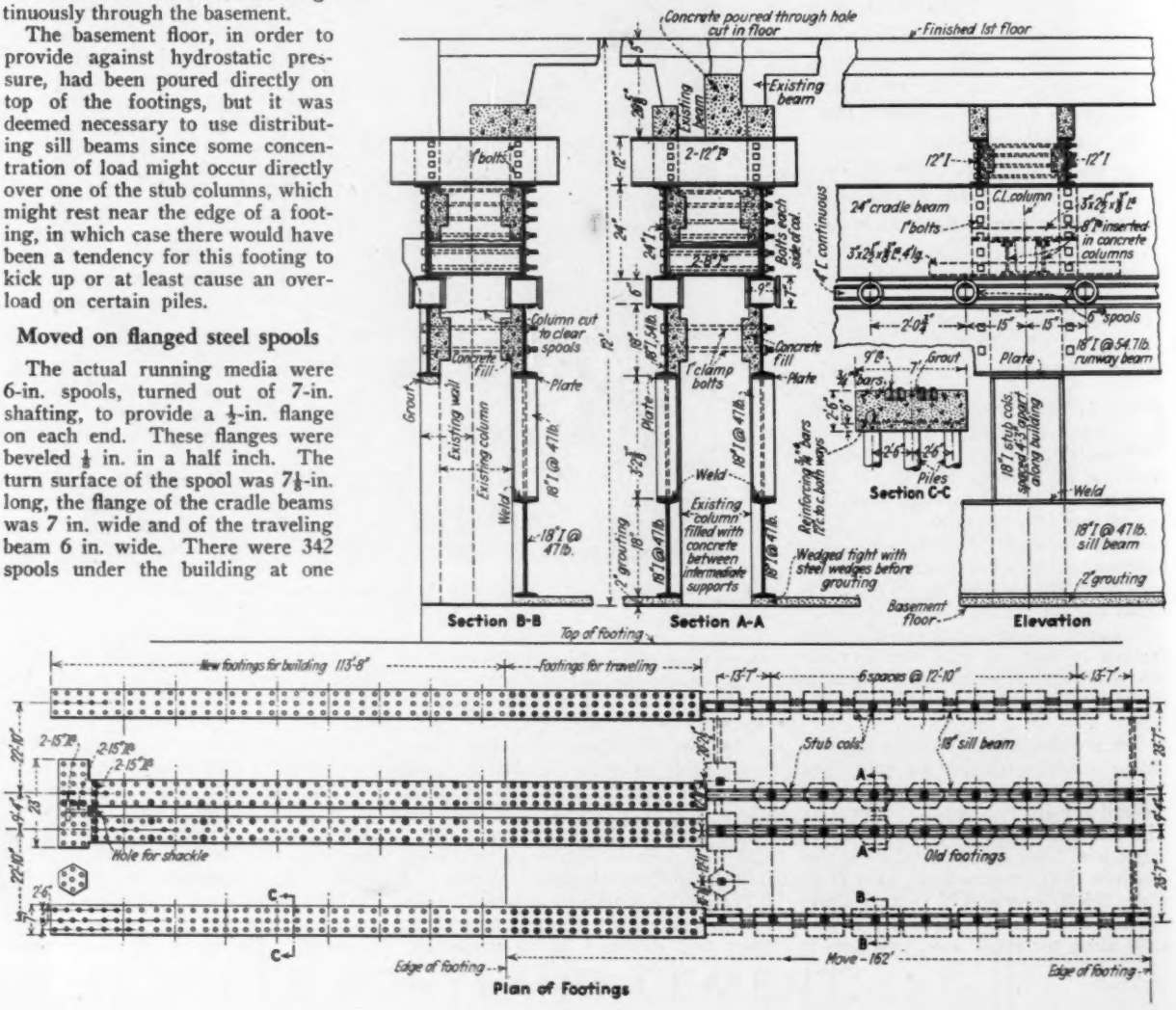
With the traveling and sill beams approximately in position, the spools were set on top of the traveling beams and then the sill beams were raised with heavy steel wedges, a total of 640 being used. Wedged up tight the sill beams were grouted in. The runway and new foundation were then completed level with the runway beams and equipped with a running surface consisting of two channels spaced 1 in. apart back to back and grouted tightly under the flanges.

The motive power for moving the building was supplied by a 10x12-in. steam engine working through one set of 8-sheave blocks and one set of emergency 4-sheave blocks. The blocks were fastened to the cradle at $\frac{1}{3}$ the length of the building forward from the rear and were anchored into the continuous footing at the fore end of the travel. Since the point of pull was centered on the building, it was necessary to cross-brace the cradle in order to transmit the pull from the block fastenings to the outer column lines without perceptible deflection.

As a matter of fact, deflection governed the size of practically all members, since it was highly desirable that the load be uniformly distributed on all spools so that there would be no tendency for the spools to crowd, as they would in the event some were stressed more than others.

In order to check the movement of the building and its actions as it was moving, a transit was set up on a parallel line with sights on cross-arms, to give the line and level at both ends of the building at the same time. When everything was in readiness, a preliminary pull was made and considerable difficulty was experienced in getting the building started; this initial pull was about 615,000 lb. Then it was found that dust had accumulated in front of each roller in spite of our utmost precautions. Once over the dust chocks, it required practically a uniform pull of 338,000 lb. to keep the build-

DETAILS of supporting structure and foundations used in moving the building.

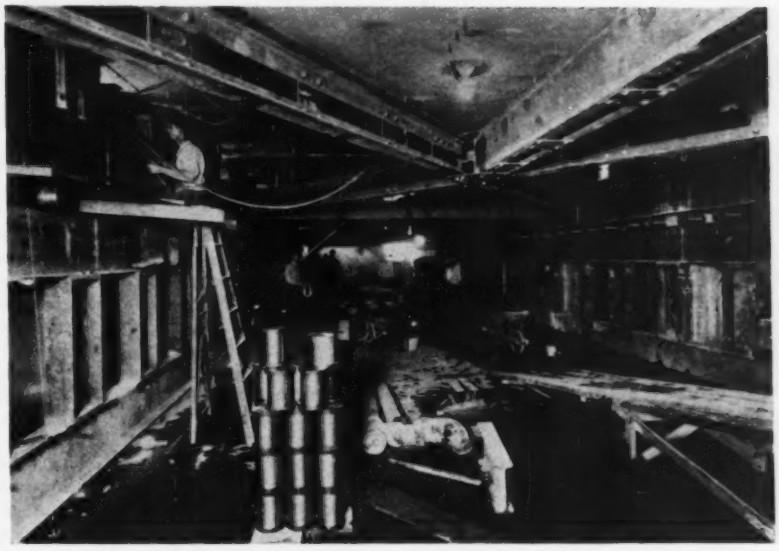


ing moving. The total elapsed time for moving the 162 ft. was 1 hr. 58 min. The actual traveling time was 20 min., since it was necessary to stop for readjustment of spools and pull cables.

Progress of the building was carefully noted and checked. As the front end of the building went onto the new runway structure it went down ⅛ in. When the entire building was on the new foundation, the rear of the building went down a corresponding ⅛ in., and the building was then level, in which condition it moved to its final resting place. After the building was free of the run beams and steel supporting structure in the old basement, this steel supporting structure rose ¼ in.

During the first 24 hours after the building was moved it settled ¼ in. The next 48 hr. showed another ¼-in. settlement. Ten days after the moving, the building apparently came to rest at ¾ in. below its original level. No cracks were visible in any of the plaster or brickwork of the building.

After the building arrived at its final location, the columns were grouted down to the new foundation, all rollers were encased in heavy grease, and then the cradle beams were grouted in leaving the rollers in place, as it is probable that the building may have to be moved again when additional ground may be acquired to accommodate the new structures planned for the Charity Hospital.



INSTALLING STEEL SHORING AND BRACING in basement of the building preparatory to moving. Steel spools are in place and wedges have been driven between sill beams and basement floor to give the spools bearing on cradle beams attached to building columns.

The work was carried out under the personal supervision of Leon C. Weiss, head of the firm of Weiss, Dreyfous & Seiferth, architects, New Orleans. It was planned and designed by the writer and executed by J. L. V. Grenier, vice-president, W. Horace Williams Co., Inc., New Orleans.

Smelter Stack of Concrete Rises to 413-Ft. Height in Utah

Highest concrete stack in United States, designed to handle 1,000,000 cu.ft. of gas per minute, is protected from acid fumes by sodium-silicate solution and shale-brick lining

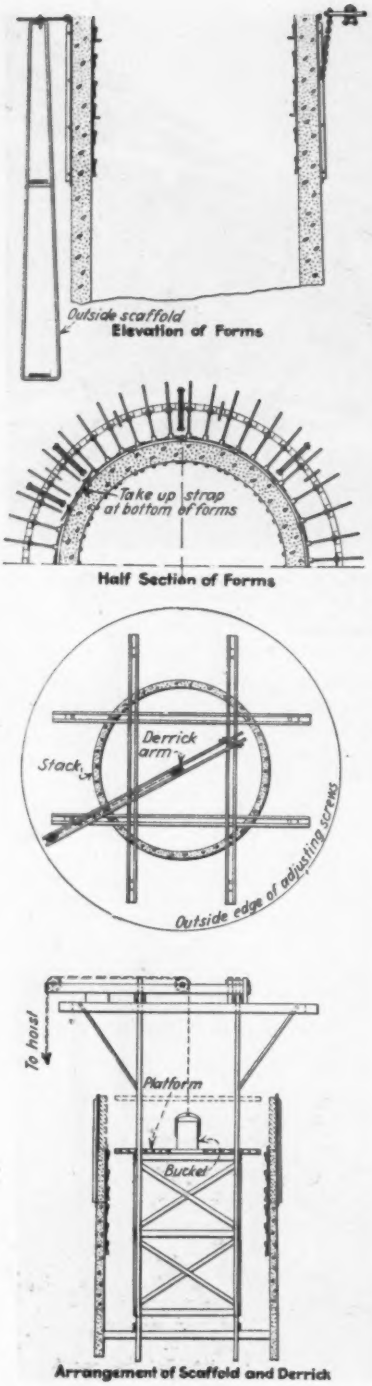
By E. B. Spencer and E. H. McDermott
Rust Engineering Co., Pittsburgh, Pa.

THE LARGEST reinforced-concrete chimney built since 1927 when the Rust Engineering Co. completed the 422-ft. chimney for the Horne Copper Co. at Noranda, Quebec, was erected at the plant of the American Smelting & Refining Co., Garfield, Utah, late last year. This chimney, the largest in the United States, is 413½ ft. high with an internal diameter of 27 ft. at the top and serves to carry off gases from reverberatory furnaces and roasters in the copper smelting plant. It is designed to handle a volume of 1,000,000 cu.ft. of gas per minute, the gases having a temperature varying from 150 to 350 deg. F., with an average of 250 deg. and containing varying percentages of SO_3 and SO_2.

Prior to the construction of the chimney, the soil was tested and found capable of supporting a safe load of 5 tons per sq.ft. The resulting foundation is a 55½-ft. octagon, 8½ ft. thick. It contains 150 steel dowels, 1 in. square, which project up as reinforcing into the first two sections of the concrete of the chimney. From these dowels the vertical reinforcing extends upward, so arranged that the laps in the alternate bars are located 15 ft. apart vertically, avoiding a continuous row of laps around the periphery of the wall at any point. At the flue additional reinforcing, both horizontal and vertical, is added to transfer the stresses around the opening, and to take care of temperature stresses.

The design of the chimney is based on the usual method for reinforced cantilever-beam construction, with a foundation sufficiently heavy to offset the overturning moment due to a 100-m.p.h. wind. The concrete was designed to use 5½ gal. of water per sack of cement in the top 100 ft., 6 gal. per sack in the bottom 305 ft. and 6¼ gal. per sack in the foundation; these variations gave concrete ranging in strength from to 3,500 to 2,500 lb. per sq.in. in 28 days. Steel was figured at 18,000 lb. per sq.in. Using these considerations as a basis of design, a wall was obtained 7 in. thick at the top, increasing to 30 in. at the bottom, with reinforcing varying from 19 sq.in. in a section at the top to 150 sq.in. at the bottom. Horizontal reinforcing con-

NEW AND OLD smelter stacks at Garfield, Utah, as dynamite removed the latter, a 300-ft. brick structure, from service.



FORMS and scaffolding used to construct a 413-ft. brick-lined concrete smelter stack.

sists of ½-in. round bars at 12-in. centers, reduced to 6-in. centers at critical points.

Before installing the lining, the inside of the concrete wall was given three coats of a solution of two to four parts of water and one part of sodium silicate, to provide protection for the concrete against dilute acid fumes and moisture. The sodium silicate filled the pores and furnished a glazed coating over the entire surface.

The chimney is provided with an acid-resisting lining of salt-glazed shale bricks 4½ in. thick supported on corbels at intervals of 30 ft. The combination of salt-glazed brick lining and sodium-silicate treatment has provided very effective protection in similar structures.

The top wall of the chimney is protected by a vitrified shale cap made of the same material as that used in the lining brick; this cap extends over the lining, making a weatherproof finish for the top of the concrete and brick walls. Steel steps at 15-in. centers with guards at 30-ft. centers are installed to give access to the top of the chimney. Lightning protection consists of 12 lead-covered copper points with 24 conductors.

Due to contamination of the air near the top of the chimney the top 200 ft. outside was given the sodium-silicate treatment and, in addition, two coats of asbestos-fibered gilsonite paint were applied.

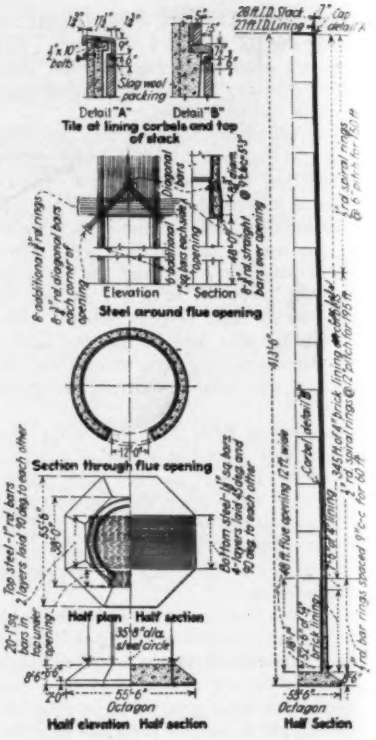
The contractor's special sectional, all-steel forms were used in erection of the concrete shell. These forms consist of external and internal segments, adjustable to any wall thickness or diameter. A scaffold is suspended from the outside of the forms for the use of workmen in making adjustments and finishing the concrete surfaces. A wooden scaffold, erected inside the chimney as work progressed, supported a "cat-head," consisting of four crossed timbers, from which the forms were suspended. Above the crossed timbers a derrick arm was installed, from which the hoisting cable extended down the inside to the concrete chute at the base and down the outside to the hoisting engine. The erection work was completed in 170 calendar days.

Demolition of old brick chimney

After the new concrete chimney was placed in operation, the old radial brick chimney that had been in use for 28 years was demolished. Since it had a height of 300 ft., a top inside diameter of 30 ft., and weighed about 6,000 tons, it was important that extreme care be exercised in the process of dropping the chimney.

The top of the foundation was at grade level. The base, or first 40 ft. of the chimney, was built of common brick with breeching openings on opposite sides extending 26½ ft. high and 14 ft. wide. The outside diameter of the chimney at this location was 44 ft. and the wall thickness 40 in.

The line of fall desired was in line with the breeching openings and away from the plant. Air tools were used to cut away the brickwork, beginning at the front and working toward each side. Heavy timbers of proper size were wedged in place on end in the opening as the work progressed; preparations were made at this time to insert dynamite under the timbers. When the cutting, which tapered downward, had reached a point beyond the center on each side of the stack, the timbers took the load, as the stack was thrown slightly off balance.



DESIGN DETAILS of largest concrete stack in the United States.

With this method only 35 lb. of dynamite was required to raze the stack, which fell exactly according to expectations.

The chimney was designed and erected by the Rust Engineering Co., Pittsburgh, Pa., under the supervision of A. B. Patterson and H. V. Arnold, and under the direction of N. L. Stewart, assistant chief engineer of the American Smelting & Refining Company, western department.

Stainless Steel to Prevent Vegetation in River

Stainless steel is being put to a novel use in England. Engineers constructing a weir for the Derwent Valley Water Board, near Sheffield, are lining a riverbed with it. An old weir on the Derwent River is being demolished to make way for a measuring channel to check the flow of water down the river. To prevent the channel from becoming choked by vegetable growth and moss, the stone and concrete of which the bed is made, is being covered with plates of stainless steel.

The Possibilities of Puzzolanas in Mortars and Concretes

By Edw. W. Scripture, Jr.
Director, Master Builders Research Laboratories Cleveland, Ohio

• **Chemically active materials of natural, treated or artificial origin, adaptable as a cement blend or as a concrete admixture, are available to the engineer to serve in the role of "lime-fixer" for the cement, reducing solubility and hence susceptibility to corrosion and weathering, and also in some cases permitting a reduction in water-cement ratio with a paradoxical improvement of workability, thus reducing volume change and enhancing durability.**

• **The advantages and the pitfalls that accompany the use of puzzolanas are analyzed by Dr. Scripture.**

ALTHOUGH puzzolanic materials have been quite widely used abroad, it is only recently that they have assumed much prominence in this country. Following use of local deposits by the early Greek colonists of Pozzuoli (whence the name), the Romans employed similar volcanic dusts from other parts of Italy in their engineering works. Such materials have continued in use to the present time in Italy. In Germany, trass and Santorin have served similarly, while in England perhaps the first and most outstanding case was the building of the Eddystone lighthouse. In France, a puzzolanic material, prepared by heat treatment and known as gaize, has gone into the construction of sea works. In spite of many successful structures in these European countries, only a few installations using puzzolanic materials have been made in the United States. Most notable of these, known to the writer, are the Los Angeles aqueduct and two dams erected by the Bureau of Reclamation. The first of these seems to have failed to give complete satisfaction, possibly due to the use of an unsuitable puzzolana, while the second was more in the nature of a sand cement.

The reason for neglect of puzzolanic materials in the United States in the face of fairly widespread and successful use abroad is probably that efforts to improve concrete have been directed along other lines. On account of failures with different kinds of cement, the development of a rather restrictive standard for portland cement has been favored. Even without this the demands of modern construction methods have fostered work on high-early strength, leading in the opposite direction to the purposes sought in puzzolanic blends. Finally, much of the work on concrete has been devoted to the methods of application with respect to granulometric composition, water ratio and methods of placing. In the course of time, however, it has become apparent that, while all of these lines of research have been most beneficial, they have by no means provided a complete solution to the problem of permanent concrete, especially with respect to some of the more exacting conditions of service. As the defects of old structures have become apparent, interest in hitherto neglected means of improving concrete has revived. That attention is now being directed to one such approach to better concrete, the application of puzzolanic materials, is seen in the appearance on the market of several blended puzzolan-cements and puzzolanic admixtures and their use in a number of recent structures, of which the Golden Gate and the San Francisco-Oakland bridges are best known.

What is a puzzolana?

It has been fairly generally accepted that a puzzolanic material is one which possesses constituents that will combine with lime at ordinary temperatures in the presence of moisture to form insoluble compounds of cementitious value. (See Hughes & Levens, *Journal*, American Concrete Institute, December, 1930.) Such a definition is rather vague in that it is purely qualitative, and it would seem desirable to make it more precise by adding at least the clauses that the reaction shall take place with reasonable speed and that the combination shall proceed to an appreciable degree. With further knowledge it might be possible to fix minima for these.

While the general nature of puzzolanic materials receives fairly general acceptance, there has been little agreement on methods of test and standards for evaluation. Direct measurements have been made of the combination of lime with the puzzolana by chemical analysis, by electrical-conductivity determinations and by observation of volume increase of a mixture of puzzolana and lime. Indirectly evaluation has been attempted by weathering tests, corrosion tests, sodium-sulphate tests (in which the progress of the reaction has been observed by loss of strength) by loss of weight, by volume changes or simply by appearance. Again the quantity of lime which may be leached from mortar specimens by distilled water under certain fixed conditions has been used as a measure of puzzolanic activity. Attempts have been made to relate puzzolanic activity to the chemical analysis or to the "soluble" silica content. Finally strength tests of mixtures of lime and the puzzolana frequently have been employed.

To comply with the usual definition, it would seem necessary to show that the material in question does two things: it must combine with lime, and it must develop strength when in contact with lime. The indirect methods, although they may give valuable information with respect to the gross effect on durability or other properties, are open to the objection that the observed results may be attributable to puzzolanic activity but may equally well be attributable to some entirely different cause. A direct determination by chemical means of the quantity of lime which a material will remove from solution under fixed conditions seems a more satisfactory means of securing at least comparative values for both the amount of reaction and the rate at which it proceeds. Strength determinations on mixtures of lime and the puzzolana stored out of contact with the air will show that the material complies with the second requirement.

Various kinds of puzzolanas

The rather indefinite definition of a puzzolana and the lack of any quantitative standards for puzzolanic activity permit the inclusion of a wide variety of materials under this term, and these may be divided into three groups—natural, treated and artificial. Among natural products are the volcanic earths, distributed quite widely throughout the world and found in the western part of the United States, and diatomaceous earths of vegetable origin. The latter are distributed widely throughout the United States from New Hampshire to California and in numerous deposits in most countries. Some other natural materials of a siliceous nature show puz-

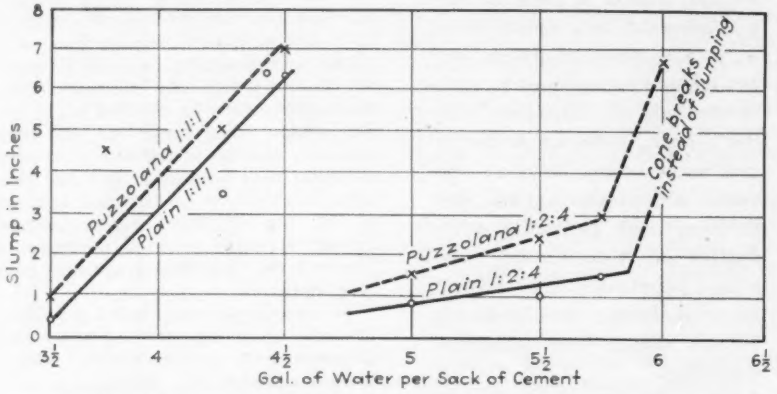
zolanic properties. The treated puzzolanas are generally clays or shales that have been subjected to a burning process. More of less suitable deposits may be found in almost any locality. The artificial group includes silica residues from heavy chemical industry, many slags, clinkers, silica gel and similar byproducts.

The chemical composition is in no way restricted by the definition, but most of all puzzolanic materials contain silica, many alumina and a fair number iron, present as free silica, alumino-silicates or ferro-silicates. Other chemical elements may also be present. While it has been very generally thought that the puzzolanic action was one of combination of lime with some active form of silica, it probably includes the formation of other compounds such as calcium alumino-silicates. The precise nature of the reaction is not clearly understood; it may be a direct combination of lime with silica or a silicate, it may be a replacement of a part of the silicate by lime, similar to the action of zeolites, and it may be an adsorption of lime on the silicate. In materials that show a substantial degree of reactivity chemical reaction almost certainly takes place while replacement and adsorption are also probably involved.

These reactions take place at the surface so that their rate and their completeness are more dependent on the physical form of the puzzolana than on chemical composition. For this reason amorphous or microcrystalline materials like the volcanic dusts or diatomaceous earths show more pronounced activity than crystalline silica or silicates. For the same reason the puzzolanic activity increases with greater fineness. Consequently, within limits, the degree of puzzolanic activity is governed more by structure and fineness than by composition. Almost any siliceous material—for example, a quartz sand—will show some puzzolanic activity, but unless the mineral is very finely ground the amount will be so small that it escapes detection by ordinary means. It is only the materials that have developed a very large surface by natural means (as in the case of diatomaceous earths and tuffs), by treatment (as with burned clays), or by their method of preparation (as with gels, slags and chemical residues) that show a significant degree of activity. The only sound method of identifying a material as puzzolanic is to require that it show a substantial reaction with lime.

Degree of activity

In view of the great diversity of available puzzolanic materials, it is a matter of considerable interest to inquire into their relative reactivities. Two factors are involved: the quantity of lime that will combine with a given quantity of puzzolana and the rate at which this occurs. A method which permits the reaction to be followed from day to day and also has the advantage of simplicity is that of determining by chemical analysis the lime absorbed from a saturated lime solution by a fixed quantity of the puzzolana. Some results secured by such a method are shown in Table 1.



TEST RESULTS OF A PUZZOLANA which permitted a reduced water-cement ratio while at the same time increasing the workability as measured by slump. Puzzolana was added in the amount of 3 lb. per sack of cement.

TABEL I—LIME ABSORPTION BY PUZZOLANAS

Gr. (CaO) Absorbed per Gr. of Pussolana

Material (5 gr. in 2 liters)	4 Days	7 Days
Silica, 325-mesh	0.009	0.011
Diatomaceous earth	0.018	0.036
Fly ash	0.000	0.000
Volcanic dust	0.007	0.012
Bauxite residue	0.066	0.093
Synthetic alumino-silicate	0.226	0.278
Silica (artificially prepared)	0.318	0.399

A pure lime acquires strength by the slow absorption of carbon dioxide from the air, forming calcium carbonate, a reaction which proceeds very slowly in from the surface and at a diminishing rate. If a puzzolana is mixed with the lime, strength is acquired by reaction of the two, to form calcium silicates throughout the mass. Such a mixture is virtually the same thing as the so-called "hydraulic limes" and can be used under water, whereas a pure lime can only be used in air. With the hydraulic limes and portland cements available at the present time, puzzolan-lime mixtures are no longer a factor. The important application of puzzolanic materials is as an addition to portland cement or as a mixture in which the puzzolana replaces part of the cement. Portland cement is made up largely of compounds that form hydrates with water to acquire strength, and it is consequently in no way dependent on the atmosphere. Most portland cements, however, contain small proportions of free lime—that is, lime not already combined with other constituents of the cement. During hydration more free lime is produced by hydrolysis of the calcium silicates of the cement, so that the total may amount to as much as 17 per cent, though often less, depending on the original composition of the cement and the degree of hydration attained during curing. It is with this free lime that a puzzolanic material may react to form additional cementitious compounds.

When a puzzolanic material is used as an admixture, the strength, compressive or tensile, will be increased in so far as the puzzolana forms cementitious compounds with the free lime. As the admixture can only be used in comparatively small proportions, this is not a very important factor.

TABLE 2—COMPRESSIVE STRENGTH OF STANDARD SAND MORTAR

(Cured 24 hr. in moist room, then in water)

	Compressive Strength—Lb. per Sq.In.		
	3 Days	7 Days	28 Days
1:3 mortar	1557	2295	2909
1:3 mortar + 8% synthetic pussolana	1823	2775	3587

Slow reaction a feature

When the proportion of cement is decreased and an equal amount of puzzolanic material added, the effect is to decrease early strength, but after six months or a year the strength of the blend will equal or exceed that of the cement alone. In this connection it must be noted that the slow development of strength from the puzzolanic reaction can only be realized if the concrete is kept damp. In the type of construction in which the concrete is cured for a few days or weeks, as in general building construction, and then allowed to dry out, no benefit can be derived from a puzzolana that reacts slowly whereas in a structure that is constantly in contact with water, as a seawall, the puzzolanic action can continue over a long period of time to completion.

In the placing of large masses of concrete, the quantity of heat evolved by the cement during hydration, especially during the first few days, is a matter of considerable moment. Rapid heat evolution raises the temperature within the mass to a high point; during subsequent cooling, contraction causes strains and cracks. The quantity of heat evolved by combination of a puzzolana with lime is not definitely known, but because the reaction is slow it does not contribute substantially to the rise of temperature in a concrete mass. Consequently, a puzzo-

lana used as an admixture will not have any appreciable effect on temperature, but used as a blend in which the cement is decreased and replaced by puzzolana it will diminish the heat evolution practically in proportion to the percentage decrease in cement. The puzzolan cements, therefore, constitute one class of low-early-strength, low-heat cements which may be used to minimize cracking from volume change due to temperature rise.

Cement solubility decreased

It has been said that portland cement is entirely soluble in water if enough water is used, but most of the compounds of portland cement are soluble only with great difficulty. The most soluble is the free lime. By combination with silica or an alumino-silicate it is rendered much less soluble, so that in the presence of percolating water the cement is less easily dissolved and penetration of water is retarded. This is of significance in promoting watertightness and in decreasing the danger of efflorescence—that is, the bringing of soluble materials to the surface, which is especially objectionable in brick mortars. While the disintegration of concrete and mortar by dissolution in water alone is a comparatively slow process, corrosive solutions formed from the acid impurities in the air, from various soluble compounds in the earth or introduced by man greatly accelerate this action, so that it becomes a serious menace. Reduction of solubility by puzzolanic action will minimize the effects of these disintegrating forces.

Use as blend or admixture

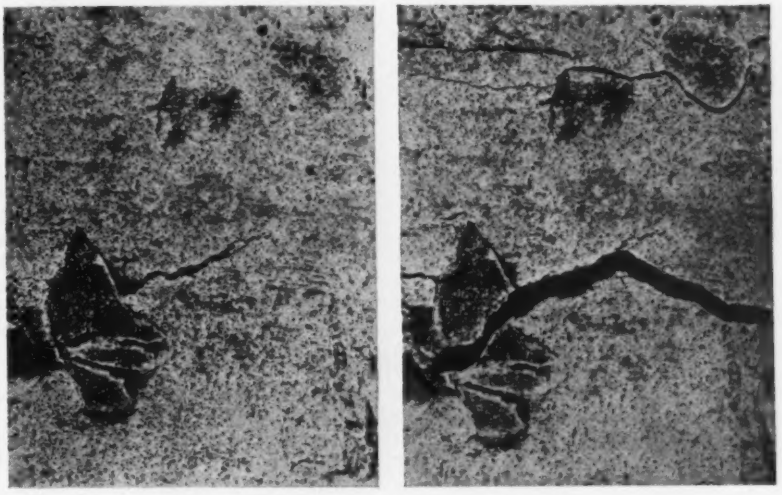
The puzzolana may be introduced into the concrete either as a blend or as an admixture. In the first case a comparatively large proportion of puzzolana is ground with portland cement clinker; in the second a small percentage of a relatively more reactive puzzolana is added at the time of mixing the concrete. The blend has the advantage of intimate mixing, of permitting the use of relatively less expensive materials and of reducing heat evolution. It has the disadvantage that desirable properties, as strength and volume change, may be adversely affected, that the water-cement relation is disturbed, and that suitable materials are not available in all localities. Suitable admixtures have the advantage that they do not materially affect the water requirement or other properties of the cement, that they can be economically shipped to any point, that they can be conveniently handled on large or small jobs, and that a higher degree and rate of activity can be secured, although they do not reduce heat evolution. The only sound basis of selection is to balance the cost per yard of concrete against the results obtainable with blend or admixture as shown by tests of strength, water ratio, corrosion resistance and other properties required in each particular case.

Cements for use with puzzolanas

Two other questions which naturally arise concern the type of cement to be used with a puzzolana and the proportions of cement and puzzolana. Since the function of the puzzolana is to combine with the free lime, its proportion should be governed by the amount of free lime in a particular cement. This quantity is not easily found by a direct determination of free lime and puzzolanic activity, because the latter varies with the method of test and also with the conditions under which the concrete is actually placed. It is probably best to rely on tests showing the improvements to be effected in properties of special importance to the job in question, as strength, water ratio, or corrosion resistance. Similarly the type of cement to be used is regulated by the requirements of the job. Where heat evolution is a prime factor, a low-heat cement is indicated; where drying shrinkage is more important, a cement requiring a small amount of water for workability is necessary. Since most cements will contain, after hydration, a considerable proportion of free lime, and the function of a puzzolana is to combine with this lime during curing, puzzolanic materials will be effective with either high- or low-lime cements. Furthermore, no purpose is served by adding lime and puzzolana to the cement, a measure which simply nullifies the benefits to be derived from the puzzolana.

Influence on concrete properties

Three attributes of concrete and mortar are very closely related: workability, volume change and water ratio. A certain amount of water is required to hydrate portland cement. It has been fully established that compressive strength increases with the decrease in water used in porportion to cement. It can equally well be shown that the porosity or void content decreases with diminishing water in the mix. Finally, it will be generally conceded that volume changes, shrinkage and expansion will be smaller with less water. All these desirable properties may be secured by reducing the amount of mixing water used, but the concrete must be workable, and for this a certain amount of water is necessary over and above that required for hydration.



EFFECTS OF EARLY SHRINKAGE in a 1:3 mortar specimen shown by photomicrographs of 40 magnifications. After 7 days' curing in moist air (left) incipient cracks have developed around the sand grains. Same specimen under a small compressive stress applied by a screw clamp (right) shows further development of the cracks.

Increased strength and density have received a great deal of attention, but the subject of volume change, although not entirely neglected, has not been granted the significance that it deserves. During and after hardening, any mortar or concrete undergoes a series of changes in volume which seriously affect its final condition. At first, as it rapidly loses water, large shrinkages occur; during curing, the volume remains nearly constant or expands slightly; on drying out after curing, a further contraction is observable; and, if subject to wetting and drying, further alternate expansions and contractions are produced.

The effects of early shrinkage phenomena are illustrated in the accompanying photo-micrographs. In the first is shown the shrinkage cracks that develop in the cement paste, especially around particles of aggregate. These are usually only visible under the microscope, but under severe conditions of placing they may attain a size at which they are readily seen with the naked eye. In one recent instance of a pavement constructed under rather adverse circumstances, cracks several feet long and up to ¼ in. wide developed within

5 hours of placing. The second photomicrograph shows that, contrary to general belief, these shrinkage cracks are opened up and increased in size under compressive loads. As would be expected, they are also opened up under loads in shear and in tension. Whatever the size or number of these cracks, it must be evident that they offer points of attack for the entrance of water and corrosive solutions, and that they are a source of weakness accelerating the rate of disintegration by all the forces tending to destroy concrete. Even where the cracks have not actually developed, the volume changes taking place in concrete tend to produce local strains that are similar points of weakness. Lacking a method of eliminating volume change, the importance of reducing it by using as little water as possible will be clear.

Slump comparisons

It has been aptly said that the benefits to be derived from any admixture must be great enough to compensate for the disadvantage entailed by the necessity of using additional water. This is especially applicable to puzzolanic admixtures, since they generally require more water than the same mix without puzzolana. Actually, puzzolanas may be divided into three classes on the basis of water required for workability: those which need a considerable increase in water to give workability, those which have little or no effect on the water required, and those which permit a reduction in water. The first class is fairly numerous and in general shows a fairly high degree of puzzolanic activity; the second class is also numerous but generally exhibits little activity; and the third group, while not numerous, shows high activity. In the case of puzzolan cements much the same relations hold, and the same three classes exist. The relation between workability as measured by slump and water ratio for a puzzolana of the group, permitting reduction in water, is shown in the accompanying graph.

Slump is a measure of consistency rather than of workability, but in a given mix it will measure the amount of water required for a placeable concrete and may be said to determine "mobility." A less tangible aspect of workability is the property often described as "fatness," especially with reference to brick mortar. Most puzzolanic materials, whether used as admixture or as replacement for part of the cement, enhance this characteristic of a concrete or mortar. Unfortunately, this is a function not easily measured quantitatively, but there is undoubtedly a wide variation in the degree in which it is conferred by different puzzolanas.

In considering the usefulness of a puzzolanic material it is necesssary to know its characteristics and to weigh the benefits against the disadvantages. Certainly the puzzolana should have a high degree of activity, it should promote workability as described by the word "fatness," and it should, if possible, decrease volume change by requiring less water for placeability.

Volume-change relations

The use of a puzzolan cement or a puzzolanic admixture can and may improve concrete by making it more durable in three ways: It can reduce the danger of failure due to crazing, checking and cracking by decreasing volume changes. It can increase the resistance to corrosion by solutions that tend to attack portland cement. It can improve resistance to the disruptive action of freezing and thawing.

In so far as the puzzolana permits a reduction in water, as has been discussed above, volume changes and the resultant checking and crazing will be reduced. Furthermore, since lime and a puzzolana apparently combine to form a compound whose volume is greater than the sum of the volumes of the two reacting materials, the net effect of the puzzolanic action is to decrease the final shrinkage. This is illustrated by the figures given in Table 3 for the expansion during curing of concrete cylinders made with and without a puzzolanic addition.

TABLE 3—EXPANSION OF 1x1x6 PRISMS IN MOIST CHAMBER
(Mix 1:3 graded bank sand mortar)

Time	No Puzzolana	With Puzzolana
3 Days	.000044	.000044
7 Days	.000139	.000139
14 Days	.000150	.000155
28 Days	.000155	.000178

*3 lb. per sack of cement.

Corrosion resistance

Portland cement is attacked by corrosive solutions in two ways. One type, generally acid solutions, tends to dissolve the cement, first the free lime then the other compounds. The other type, sulphate solutions, combines with the aluminates to form calcium sulphoaluminate. This compound occupies a considerably greater volume than the original calcium aluminate and therefore disrupts the cement structure. Puzzolanas greatly retard these disintegrating effects by several means. In so far as porosity is lowered and microscopic shrinkage cracks are decreased, penetration of the attacking solution is prevented or slowed up. Combination of the most soluble portion of the cement (lime) with the puzzolana lowers the solubility of the cement generally and makes the progress of what solution does occur much slower. Similarly, the combination of the puzzolana with the cement seems to prevent its combination with sulphates. The resistance to corrosive agencies which is conferred on cement by addition of a puzzolana is shown in Table 4.

Freezing damage

Over a wide area in this country concrete structures are subject to destruction from freezing and thawing. Water enters into the pores or cracks in the concrete, is frozen, expands and breaks down the cement. Obviously the more frequent the cycles of freezing and thawing the more destructive is this action. In the warmer parts of the country where freezing is seldom or never encountered this is of no consequence. In the more northern regions where the water freezes up in the fall and remains frozen until spring, giving only one cycle per annum, the damage progresses only slowly. In the section between where frequent changes of weather produce a number of cycles in the year the disintegration is most rapid. As they do in the case of corrosive attack, puzzolanas promote resistance to freezing and thawing by lowering the porosity and reducing shrinkage cracks. They further help by making the cement less soluble, thus preventing the growth of channels through which water can enter. Table 5 gives the results of tests in cycles of freezing and thawing, both in plain water and accelerated by the use of a sodium-sulphate solution.

Selecting puzzolanas

The possible applications of puzzolanas in concrete and mortar have by no means been exhausted, as they cover the

TABLE 4—CORROSION RESISTANCE OF STANDARD SAND MORTAR
(Puzzolana—3 lb. per sack of cement)

	Compressive Strength—Lb. per Sq.In.	
	28 Days in Water	21 Days 10% Sod. Sulphate
1:3 mortar	3750	3500
1:3 mortar with puzzolana	4487	4400
	5½ Months in Water	4½ months in 8% Mag. Sulphate
1:3 mortar	4487	3501
1:3 mortar with puzzolana	4581	4105
	3 Months in Water	2 Months in 1% Acetic Acid
1:3 mortar	4551	3501
1:3 mortar with puzzolana	4536	4106

Note: Difference in time between storage in water and in corrosive solution represents water curing before exposure to corrosion.

TABLE 5—RESISTANCE TO FREEZING AND THAWING

	Compressive Strength—Lb. per Sq.In.		
	In Water 3 Months	25 Cycles Freezing and Thawing Alternated with Sod. Sulphate	50 Cycles of Freezing & Thawing
1:6 mortar*	2991	2269	1592
1:6 mortar with puzzolana†	3403	3215	2545

*1 part cement, 2 parts graded bank sand, 4 parts ¼- to ½-in. gravel.
†Puzzolana 3 lb. per sack of cement.

whole range of construction. It does not, however, follow that a single material or method is applicable to all types of work. It is necessary to fit the puzzolana to the specific purpose. In massive structures the reduction of heat evolution, which may be most important, can be secured with a low-heat cement and a reactive puzzolana or with a puzzolan blend. In structures exposed to sea water, resistance to corrosion is attained by combining a puzzolana with low-calcium and low-aluminate cement. In both, decrease in volume changes by a reduction of the water-ratio through the use of a puzzolana requiring less water is to be sought. In concrete, both plain and reinforced, of less massive type such as prevails in ordinary building construction, rapid development of strength and speedy completion of the puzzolanic action must be considered on account of the limited curing which it receives. In such uses a puzzolana of low rate of activity is useless, for the cement must develop strength at at least a normal rate, and the puzzolana must be such that its combination with lime takes place within a short time. Resistance to freezing and thawing is to be sought by the use of a puzzolana that reduces the water required for workability. Floors and similar surfaces are often subjected to severe corrosive conditions. Here resistance is secured by decreasing solubility with puzzolana and a cement having low free lime, and by preventing crazing and checking by reduction of water. Colored floors are susceptible to clouding of the colors by soluble salts, and in so far as it is possible to combine the lime of the cement with a puzzolana this may be eliminated.

Brick mortars require several properties that are difficult to secure simultaneously—workability, low volume change, corrosion resistance, resistance to freezing and thawing, watertightness and low solubility. It is hardly possible to treat this complex and rather controversial subject briefly, but a highly reactive puzzolana which reduces water required for workability is very beneficial with any brick mortar. The type of cement to be used, the relative proportions of lime and the inclusion of a stearate are subjets on which no unanimity of opinion exists.

To secure the best results in using puzzolanas, it is necessary that the engineer be able to specify suitable cements and puzzolanic materials. With respect to the cements, some standards are already available to permit selection on the basis of heat evolution, strength and resistance to sulphate waters. (See paper by P. H. Bates, *Journal*, American Concrete Institute, Jan.-Feb., 1935.) Some reliable method of test for the reactivity of a puzzolanic admixture is required, and for this purpose the absorption of lime from a lime solution under fixed conditions seems simplest and most direct. At the same time some means of evaluating workability is desirable. Although by no means entirely adequate, the slump tests under selected conditions serve practical purposes fairly well. It is then possible to specify a minimum with respect to the amount of lime absorbed in a given time and a maximum water content for the required slump, so that a suitable puzzolana can be selected and the proportion to be used determined from test data on strength, volume change and resistance to destructive agencies.

With a blended puzzolan cement, the properties of the puzzolana used can be determined less easily. In this case the specifications can be based on tests of the clinker and the puzzolana before intergrinding, or on indirect tests made with the blend itself. Whether used as an admixture or in a blended cement, enough puzzolana should be used to combine with as much of the free lime as possible. It is hardly possible to use an excess as long as compressive strengths are not reduced too far or size-distribution relations of the concrete are not upset by introduction of too large a proportion of fines. The real danger lies in failure to use enough puzzolana or a puzzolana of sufficient reactivity to produce a significant effect.

It is to be expected that the renewed interest in puzzolanic materials will bring about their application to a wide field of usefulness. That materials which reduce solubility by combining with the free lime of portland cement are of value is borne out by their history. If at the same time control and reduction of water-cement ratio, while maintaining or enhancing workability, can be effected, they become of importance in relation to volume change. Benefits are also to be derived from decreasing the rate of heat evolution with puzzolanic blends.

At the present time sufficient information is available to permit the use of puzzolanic admixtures and puzzolan cements with confidence. However, care should be exercised in their selection, to secure materials suitable for the purpose.

With the further study which recent developments have stimulated, improvements are to be anticipated, and a clearer understanding of their proper application will be possible.

Dissolved Solids Content of Colorado River Water Analyzed

THE probable range in dissolved solids content of Colorado River water, available in the future for irrigation and for public supplies below the Boulder Dam, may be estimated from analyses made by the United States Geological Survey since 1925. Some of the significant analytical results for the 4-year period ending September 30, 1934, which have not yet been published, have been tabulated recently and made available for public inspection in offices of the Geological Survey in Washington, D. C.; Tucson, Ariz.; Los Angeles and San Francisco, Calif.; Denver, Colo.; and Salt Lake City, Utah.

The tables give the quantities of dissolved solids, in parts per million, found in 10-day composites of daily samples. Weighted annual averages are also given. One of the tables, reproduced herewith, shows the weighted average content of dissolved mineral matter at Grand Canyon, Ariz., for each of the 9 years of record. A weighted average represents approximately the composition of the thoroughly mixed contents of a reservoir holding the entire flow of the river for a year. Obviously there will not be exactly such weighted average water behind the Boulder Dam, because water will be discharged continuously from the reservoir. It seems unlikely that water drawn in future from the Boulder Reservoir will ever carry so high a concentration of dissolved solids as the weighted average of 960 p.p.m. for 1934, nor so low a concentration of solids as the weighted average of 491 p.p.m. for 1928, unless the use or diversion of water above the Boulder Dam greatly changes present conditions. The results in the table of averages suggest according to the Geological Survey that in the near future the concentration of dissolved solids in the reservoir water will probably be a little less than the weighted average of 593 p.p.m., or 0.81 ton per acre-foot, found for the 9 years ending Sept. 30, 1934. Unless water passes through the reservoir without thorough mixing, which now appears to be unlikely, or unless there are several successive years of very low discharge, the range in concentration of the dissolved mineral matter is not likely to be as much as 100 p.p.m., or 0.14 ton per acre-foot, above or below the average mentioned.

DISCHARGE AND WEIGHTED AVERAGE OF DISSOLVED SOLIDS IN COLORADO RIVER

Year Ending Sept. 30	Annual Discharge, Acre-Ft.	Dissolved Solids p.p.m.	Dissolved Solids Tons per Acre-Ft.
1926	14,400,000	523	0.71
1927	17,300,000	569	.77
1928	15,600,000	491	.67
1929	19,400,000	555	.76
1930	13,400,000	622	.85
1931	6,720,000	813	1.11
1932	16,000,000	531	.72
1933	10,000,000	635	.86
1934(1)	4,674,000	960	1.31

(1) Preliminary.

Contracts Impossible to Perform—II

A review of the law as determined by legal opinion and court decisions in many cases of past and recent legislation

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IN OUR DISCUSSION of the law governing the rights and duties of parties to a contract impossible to perform we have thus far found that where impossibility existed at the time of the making of the promises in what the parties believed to be their contract, no duty to perform ever arose and, strictly speaking, no contract was created. We also found that in cases where impossibility arose after the making of the contract the law has been developed by judicial opinion within the last century to the point where it is now settled that duties under a contract are terminated if the impossibility falls within the scope of four classes of cases, one of which we analyzed. In this class are cases where performance became impossible by reason of a change in domestic law. Let us now consider the second class of contracts, those impossible to perform because of conditions arising after the formation of the contract.

Personal-service contracts

Impossibility of performance of personal-service contracts is of particular importance to the engineer. Where death or illness renders impossible the performance of a contract that requires for its fulfillment the services of a particular person, which may not be delegated or assigned, the duties created by the contract are discharged. Suppose *A*, an engineer, enters into a contract with the *B* Construction Co. to superintend the construction of a sewer for the period of the work. When the work is partly completed *A* becomes seriously ill. His duty to perform further is discharged. His death would likewise terminate the duty to perform, and his estate would not be liable for breach of contract.

In the case of Buccini vs. Paterno Construction Co. (253 N. Y. 256), decided by the Court of Appeals in March, 1930, it appeared that Buccini made a contract with the Paterno Construction Co. to decorate the ballroom, banquet hall and swimming pool in a dwelling in New York. The work called for the exercise of artistic skill. The contract provided that all decorative figured work should be done by Buccini personally. Buccini died while the work was in progress. This suit was brought to recover for the work performed by Buccini. The court held, "The contract being personal, the effect of his death was to terminate the duty of going forward with performance, but to leave the owner liable for benefits received."

The death or illness of the employer, however, does not have the same effect. In the case of illness of the employer his duty to perform continues. In the case of his death his estate must perform.

Contracts of personal nature defined

Contracts sometimes provide for the performance of an act without any clear indication as to whether the duty to perform may or may not be delegated or assigned. The question arises as to which class the contract falls in. For if the duties may be delegated or assigned, the illness or death of the promisor will not terminate the duty to perform. In Kelley vs. Thompson Land Co. et al (164 Southeastern Reporter 667) the Supreme Court of Appeals of West Virginia in June, 1932, applied this test.

> Where the acts stipulated in an agreement require the exercise of special knowledge, genius, skill, taste, ability, experience, judgment, discretion, integrity or other personal qualification of one or both parties, the agreement is said to be of a personal nature. It seems to be an accepted rule that in contracts of this kind the death of one who was to perform a personal service shall dissolve the contract.

When illness justifies termination

Now, the question arises as to when illness of the person whose services are contracted for justifies a termination of the contract by the employer. Would illness of a temporary nature permit termination? The test is whether the illness has continued long enough to become material. Furthermore, if the employee's condition is such as to justify a reasonable belief that his incapacity will continue, his illness is considered material. In Gaynor vs. Jonas (93 N. Y., Supp. 287) it was held that where an employee who had a three-month contract was ill for 1½ days the employer was not justified in discharging him.

Fear of illness or death

Not only may death or actual illness terminate a duty to perform, but even a well-grounded fear of illness or death may have the same effect. In the case of Lakeman vs. Pollard et al (43 Maine, 463), decided by the Supreme Judicial Court of Maine in 1857, it appeared that the plaintiff refused to continue to work for the defendant as provided by his contract on the ground that a cholera epidemic had broken out in the vicinity of the mills where he was employed. The court held that:

> The plaintiff was under no obligation to imperil his life by remaining at work in the vicinity of a prevailing epidemic so dangerous in its character that a man of ordinary care and prudence in the exercise of those qualities would have been justified in leaving by reason of it, nor does it make any difference that the men who remained there at work after the plaintiff left were healthy and continued to be so.

Destruction of essential things

The courts read into contracts a third class of implied covenants—that the duty to perform shall terminate on the destruction of the specific thing essential to the performance of the contract. If *A*, for example, should undertake to paint a building owned by *B*, the continued existence of the structure is necessary to the performance of *A* by his promise. Should the building be destroyed without any fault on the part of *A*, it is clear that he cannot continue to paint. The law in this case excuses him.

In the case of Siegel Cooper & Co. vs. Eaton & Prince Co. (46 Northeastern Reporter 499), decided by the Supreme Court of Illinois in November, 1896, it appeared that the parties entered into a contract whereby the appellee agreed to construct an elevator in a building owned by the appellant. After the motor was on the foundation, but before the cars or cables were delivered or installed, the building was destroyed by fire without the fault of either party. The court held that:

> Where a man contracts to expend materials and labor on buildings belonging to and in the occupation of the employer, to be paid for on completion of the whole, and before completion the buildings are destroyed by accidental fire, the contractor is excused from completing the work.
>
> We think that the law is that where a contract is entered into with reference to the existence of a particular thing and that thing is destroyed before the time for the performance of the contract without the fault of either party, both parties are excused from performing the contract.

Absence of particular facts

It often happens that particular facts rather than specific things are essential to the performance of a promise, and that they do not exist subsequent to the formation of the contract. The courts

say that parties impliedly covenant that where particular facts other than specific things, which are by the terms of a bargain or in the contemplation of both parties necessary for the performance of a promise, subsequently do not exist, the obligation to perform is terminated.

This is best illustrated by the case of Dolan vs. Rogers (149 N. Y., 489), decided by the Court of Appeals of New York in 1896. It appears that in May, 1890, the defendant and the Buffalo & Geneva Railway Co. made a contract whereby the defendant was to build ten sections of a railroad. The contract contained the following clause:

> *Subcontracts* — Contractors shall be required to give their personal attention and supervision to the work and will not be allowed to subcontract the whole or any part of the same without consent of the railway company having been given in writing thereto.

In June, 1890, the plaintiff made an oral contract with the defendant to construct four sections of the railroad. At that time both parties knew of the said clause and that no consent to sublet had been given. After the completion of two of the four sections the railway company prevented work by the plaintiff by virtue of the said contract.

The court held that there was the implication in the contract that if performance of the contract became impossible by reason of the refusal of the railway company to permit work by the subcontractor, the parties should be released from their obligation under the contract as to future performance but should be bound as to the past.

Unanticipated difficulties no cause

Now let us turn to the other side of the picture. Mere unanticipated difficulties in the performance of a contract do not excuse the promisor. That the soil is of such condition that the cost of excavation is considerably higher than that anticipated is no excuse. If a contractor undertakes to erect a structure and during construction the structure is destroyed or damaged by tempest or fire, the contractor is, nevertheless, bound to complete and deliver or, upon failure to do so, is answerable in damages for breach of contract. (Williston on "Contracts.")

In the case of Tompkins et al vs. Dudley et al (24 N.Y., 272), decided by the Court of Appeals of New York in 1862, the plaintiffs brought an action to recover the money advanced by them on a contract to build a schoolhouse. It appears that the contract provided that the contractor make, erect, build and furnish a schoolhouse in accordance with plans and specifications. When the contract had been substantially performed by the contractor and there remained to be done a small amount of painting and the hanging of window blinds, a fire destroyed the building. Prior to the fire the building had not been accepted, nor had the keys been delivered. The court held that the contractor was not excused from completing and delivering the building and granted judgment in favor of the plaintiff.

This case is to be distinguished from the case of Siegel Cooper & Co. vs. Eaton & Prince Co., supra. In the Tompkins case the contractor agreed to erect, complete and deliver a building. This he failed to do. In the Siegel Cooper case the contractor agreed to perform work on and furnish materials for an existing building. The contract was made with the implied condition that the building should continue to exist during the performance of the contract by the contractor. The destruction of the building, which was essential to the performance of the contract, before completion of the work relieved the contractor from the duty of performing further.

In the case of School District vs. Dauchy (25 Conn., 530) the court held that the destruction by lightning of a building when nearly completed did not relieve the contractor from liability on a contract wherein he promised to build and complete a schoolhouse by a certain time.

Unanticipated difficulties do not even excuse delay. Should the contractor, after undertaking to complete by a given day, fail to carry out his promise because of inclement weather or other unforeseen difficulties, he would be liable for breach of contract. Williston in his work on contracts states:

> Vagaries of the weather are of such ordinary occurrence that possible delay from that cause should be anticipated. The parties cannot be supposed to have contracted on the assumption that the weather would be continuously favorable.

Acts of God

A distinction is sometimes attempted by engineers and by text writers on specifications between unanticipated difficulties and Acts of God. There is no difference between the two in regard to their effect on the duty of the contractor or owner to perform a contractual obligation. An Act of God is defined in Black's Law Dictionary as "An inevitable accident or casualty; an accident produced by any physical cause which is irresistible, such as lightning, tempests, perils of the seas, an inundation or earthquake."

> An Act of God, like an unforeseen difficulty, will not excuse a failure to perform a contractual duty. For where a party by his own contract charges himself with a duty, he must perform regardless of damage or delay by an Act of God, inasmuch as he might have provided in the contract against such contingency. ("Law of Contract," by Richardson.)

In the case of DeWitt C. Ward vs. Hudson River Building Co. (125 N.Y., 230), decided by the Court of Appeals of New York in 1891, it appears that the plaintiff, a contractor, entered into contracts with the defendant for the erection of certain houses. Each building agreement contained a provision that in default of completion of the work by a certain date mentioned, "The contractor should pay to the owner $10 for every day thereafter that the said work shall remain unfinished as and for liquidated damages."

The contractor, having failed to complete in the time specified, sought to excuse his delay on the ground that he was prevented from working by the storms commencing about March 12, 1888, in the state of New York and popularly known as "The Blizzard." The court held that this did not constitute a legal excuse and that the contractor was liable to the extent of $10 for each day that he was in default in accordance with the above clause.

Extension of time

Provision is ordinarily made in the contract proper or in the general clauses of the specifications granting the contractor an extension where he is delayed for reasons enumerated therein. Of course the delays mentioned must be such as are not due to any fault or neglect on the part of the contractor.

Great care must be taken, however, that the clause granting an extension of time clearly expresses the intent of the parties. For such clauses when carelessly drawn have been construed, to the great damage of one of the parties, to free the other from the duty to perform instead of merely postponing performance.

In the case of New England Concrete Construction Co. vs. Shepard & Morse Lumber Co. (107 Northeastern Reporter 917), decided by the Supreme Judicial Court of Massachusetts in 1915, it appears that the parties entered into a contract whereby the defendant agreed to manufacture and furnish the plaintiff 58,000 ft. of No. 1 maple flooring in accordance with certain specifications.

The contract contained the following provision: "All contracts are contingent upon strikes, fires, breakage of machinery, perils of navigation and all other causes beyond our control." Before any of the flooring had been manufactured or delivered, the defendant's mill was destroyed by fire. The defendant thereupon refused to perform. The court held:

> The agreement is not an absolute contract by which the defendant agreed to furnish the flooring to the plaintiff but was subject to certain conditions including the condition that the contract was contingent upon fires; that is to say, the defendant was excused from performance in the event of the happening of any of the contingencies set forth in the contract.
>
> The effect of this clause was not to extend the time of performance beyond the time limit, but wholly to relieve the plaintiff from the obligation to furnish the flooring called for by the contract.

In the case of Hull Coal & Coke Co. vs. Empire Coal & Coke Co. (113 Federal Reporter 256), decided by the United States Circuit Court of Appeals of the Fourth District in 1902, the court held that the defendant was excused from the duty to perform a contract to sell and deliver a certain tonnage of coke from January 21, 1899, to December 31, 1899, upon being prevented from doing so because of strikes, by the following clause:

> In case of strikes, accidents, deficient transportation or other cause unavoidably causing stoppage or partial stoppage of the works of the manufacturer of the coke or its shipment . . . deliveries herein contracted for may be suspended or partially suspended.

A proper clause for extension of time for the reasons above discussed may be found in the standard form of agreement issued by the American Institute of Architects.

Payment for impossible contracts

We have said that in cases where conditions arise which render performance of a contract impossible the parties are released from their duty of future performance. What compensation is the contractor entitled to for work done prior to the time when performance became impossible?

Where Compensation Is Fixed—The rule is that where compensation is fixed in the contract for the portion of the contract performed, the contractor is entitled to that compensation. Where, however, no compensation is fixed for such part performance, the contractor is entitled to the value of his work.

For example, in the case of Siegel Cooper & Co. vs. Eaton & Prince Co. supra, the contract price was $2,500. But it was provided that the contractor should receive $1,250 "when engine is on foundation and final payment to be due and payable when the elevator is put up in good running order." These payments the court found were not arbitrary but were based on the value of the work done. The fire having occurred after the motor was placed on its foundation, the court held that the contractor was entitled to the $1,250.

Where Compensation Is Not Fixed—Where, however, the contract does not fix the compensation, the situation is similar to that which arose in the case of Carroll vs. Bowersock (164 Pacific 143), decided by the Supreme Court of Kansas in 1917.

The plaintiff here sued to recover for part performance of a contract to construct a reinforced-concrete floor in a building that was destroyed by fire before the floor was completed. The rule with respect to the plaintiff's right to a judgment and its application to this case is stated in part as follows:

> The owner cannot be called on to reimburse the contractor merely because the contractor has been to expense in taking steps tending to performance. A contractor may have purchased special material to be used in repairing a house, and may have had much millwork done upon it. If the material remain in the mill, and the house burn, there can be no recovery. If the milled material be delivered at the house ready for use, and the house burn, there can be no recovery. It takes something more to make the owner liable for what the contractor has done toward performance. The owner must be benefited. He should not be enriched at the expense of the contractor. That would be unjust, and to the extent that the owner has been benefited the law may properly consider him as resting under a duty to pay . . .
>
> Applying the test stated to the facts of the present controversy, it is clear that the plaintiff should recover for the work done in cutting the old floor away from the wall and in removing such part of the old floor as was necessary . . . Likewise, the contractor should recover for the completed concrete footings.
>
> The contractor should not recover for materials furnished or labor performed in the construction of either column or floor forms. They are temporary devices, employed to give form to the structure which was to be produced . . . The contractor should not recover for either upright or floor rods, or for the labor of putting them in place. While the rods were wired together, they were not attached to the building and would not have been wrought into the structure until the concrete was poured. If the fire had not occurred, the contractor could have removed the rods without dismembering or defacing the warehouse, and the defendant could not have held the rods as amalgamated into the fabric of his structure. There should be no recovery for superintendence and use of tools, except as regards that part of the work done which had become identified with the warehouse itself.

Personal Service Contracts—In contracts for personal services, except where the compensation for the part performed is fixed, the employee or his estate is entitled to the value of the work performed. In discussing the determination of the value Justice Cardozo in the Buccini vs. Paterno case, supra, said, "The question to be determined is not the value of the work considered by itself and unrelated to the contract. The question to be determined is the benefit to the owner in advancement of the ends to be promoted by the contract."

The principles of law above outlined are the same in almost all jurisdictions. Their application, however, to particular cases is not uniform.

Large Acreage Added to National Forests

APPROVAL for purchase of more than 1,250,000 acres to be added to national forests in 25 states was recently authorized by the National Forest Reservation Commission. The approvals involve a purchase price of more than $4,500,000, one of the largest acquisition programs ever approved by the commission. Incorporation of these new areas into many of the national forests will aid materially in management for sustained yields of timber and for the continued protection of watershed values.

Heavy purchases were approved in the lake and upper Mississippi states and in the Appalachians. The largest areas approved were in the Superior National Forest, Minn. (242,584 acres) and in Mountain Lake National Forest, Va., 101,351 acres. More than 71,000 acres each were approved in Chippewa National Forest, Minn., and in Ouachita National Forest in Arkansas and Oklahoma. More than 100,000 acres were approved in the eight national forest units in Missouri, and more than 75,000 in the Monongahela National Forest, W. Va. The Cumberland National Forest, Ky., was extended southward to the Tennessee line.

Extensive purchases were made in the Southern Pine region, 17,315 acres in the Piedmont region, 10,580 acres in the Green Mountain and the White Mountain National Forests in New England, and 20,933 acres in the Sequoia National Forest in California. The California purchase covered valuable timber areas, including 400 acres of Sequoia trees.

About 15,000 acres were purchased for Michigan state forests, to be exchanged for state-owned lands within the national forests. The commission also authorized establishment of a southern addition to the Green Mountain National Forest in Vermont extending southward to the Massachusetts state line. The addition comprises about 273,000 acres in Bennington and Windham counties. The larger portion of this area is in commercial forest lying on the watersheds of the Hudson and the Connecticut rivers in a district containing many wood-working industries dependent upon a sustained supply of forest products.

An addition of 10,000 acres to the Monongahela National Forest in West Virginia was authorized by the commission. This addition is in Randolph County, in the Valley Bend and the Beverly districts on the watershed of the Tygart, Cheat, Shaver's Fork rivers and tributaries of the Monongahela.

An addition of 48,640 acres to the Kisatchee National Forest in Louisiana will bring important Southern Pine and hardwood areas under Forest Service timber management. The tract is a portion of the watershed of tributaries to the lower Mississippi River.

The purchased areas will enable the Forest Service to employ men from a number of CCC camps and other workers on forest improvement and protection jobs, road and trail work.

Limitations and Application of Structural Analysis

[*In Two Parts*]

II—To be safe in application, the results of stress analysis must be interpreted in the light of service conditions—Many factors of chance to be considered——Finally, the physical meaning of stress in a member as related to the action of the structure as a whole should be studied

BY HARDY CROSS

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IT IS WORTHWHILE here to remark, in connection with the problem of the load supported by two wires discussed in the first part of this article, that under either method of analysis the statics and the geometry are interrelated through the constants which define the physical characteristics of the bars. The procedure does not depend upon the assumption of proportionality of stress to strain nor upon any obscure assumption as to the action of the bar under load. It does, however, depend on our knowing the ratio of pull to deformation for the amount of pull which actually exists; apparently this relation can be got only from data of actual tests.

Analytical results must be interpreted

It is also important to note that the solution of even this simple problem, by any method whatever, calls for a good deal of interpretation before it can be applied to design. If the properties —especially the stress-strain relation— of this wire are definite and are definitely known, we may trace out exactly the relation of stress intensity to total load. The procedure is simple; compute the stress in each wire for values of C based on Hooke's Law; revise the values of C for the stresses thus found; recompute, and so proceed to any degree of approximation.

It will, of course, be found that after the yield point of the stiffer wire is passed, this wire "takes load less rapidly" than before. This conclusion is indicated by "common sense" (qualitative thinking about the matter) and is not indicated by what some would call "academic theory" (inadequate theory) based on Hooke's Law. If, however, after the yield point the stress in the stiffer wire is uncomfortably near to rupture, or if its action is decidedly erratic, we will not dare to depend upon the phenomena beyond the yield as an element in design.

The important point just here is that a solution of "the problem"—that is, the stresses in these wires—based on Hooke's Law is, alone, a very inadequate study of the problem, because:

(a) It fails to take account of the facts about the material (the limitations of Hooke's Law).

(b) It fails to take account of the chance elements involved (the possible erratic nature of the elastic relation after yield).

(c) It fails to interpret these elements in terms of probability of rupture (fails to throw light on the elements in factor of safety).

The elementary analysis fails because it lacks *flexibility;* it does not adapt itself to all elements in the problem. In this case the modification of method to attain such flexibility is fairly obvious. In complicated cases such modification is not obvious. But the fact remains that the usefulness of the information obtained is limited very much unless the method to be employed is flexible.

We might go farther and criticize even the modified solution here, because it takes no account of how this load is applied, whether rapidly or slowly. Dynamics then enters into the problem. We will need not only a method of solution of the problem in dynamics which can conveniently take account of the actual properties of the material, but we will need accurate knowledge from the laboratory as to those properties, especially as to the effect of time in modifying the properties. In this field the analytical procedures and the data from the laboratories are both unsatisfactory today.

Details of analysis

The purely geometrical relations of the movements in the structure—if this piece elongates or rotates so much, this point will move so far in this direction —may be deduced by various devices. We may note:

(a) The principle of virtual work, which includes Fraenkel's equation as a special case.

(b) Plain graphics. We draw the deformed structure and scale the movements. In a Williot diagram we draw the deformations but leave out the structure. There are all sorts of variations of this idea.

(c) Direct geometrical computations, preferably in the form of sketching a Williot diagram or one of its variations and then computing values in this diagram instead of scaling them.

Many tools may be used to facilitate the actual computations. Logarithms and the familiar slide-rule are examples. Today computing machines of various kinds are often convenient. Very convenient in many cases is the device of laying off distances on paper and effecting the computations by a graphical procedure.

Most graphics is merely a short cut in arithmetic having no inherent connection with mechanics at all. This is well illustrated in the analysis of arches, where the sums of various terms of the form abc, where a and b and c are definite quantities, are involved. These multiplications and summations may be performed graphically, but to do so has usually no special structural significance. Whether or not one cares to use it depends on convenience, on the precision desired and very much on personal choice. To discuss whether it is in all cases the best method is obviously futile.

Certain devices in analysis are almost entirely mnemonic. Thus, the use of area-moments translates a problem in geometry which the mathematician finds, because of his usual mode of thought, most convenient in its mathematical form, into a problem in the computation of shears, moments and reactions, which is familiar ground to the engineer. The same may be said of the column analogy. What convenience there is in the procedure is inherent not in the method itself but in the mode of thought of the engineer who is to use it.

Method may be varied

It is not necessary that all quantities in an analysis be found by the same general procedure. Thus some quantities

may be computed, either by arithmetic or in the case of continuous functions by the use of the calculus; some may be found graphically and some by the use of models, and the results combined. Often this is clearly a convenient procedure, often it leads to inaccuracy and sometimes to confusion; each case, or at least each type of problem, must be decided on its own merits.

When we consider that there are many special devices for simplifying and solving equations, it is seen that it is possible to produce many combinations of such devices. These do not constitute new methods or different methods. Novelty of arrangement alone is no virtue in this field, since the possibilities for such novelty are almost unlimited. If it gives the computer less work, if it is simple in its steps, then it is valuable.

There are a great many ways of writing and of solving the equations. All sorts of special tricks and devices are available — graphics, analogies, standard terms, tabulated values. The equations may be combined in different orders of arrangement, as where the moments are stated in terms of rotations in using the slope-deflection method, or the rotations are stated in terms of the moments in using the theorem of three moments. These equations may be solved in several different ways—by ordinary algebraic manipulations, by the use of determinants, by successive approximation, by successive convergence, sometimes by graphical methods, sometimes by use of standard solutions.

Irregularities in physical properties

It is well to emphasize that many analyses are quite inadequate for two reasons: first, they fail to take proper account of variation in property of material; second—and this is in a sense the same thing—they fail to carry the analysis on to failure of the material.

We may divide the life history of a broken structural specimen into four parts. In the early stages of loading, initial irregularities are being eliminated; this stage is commonly of little interest to the designer. The next stage is that of working stresses; in this stage the specimen acts in a regular way, and conventional analysis is usually a pretty good guide to its performance. Later, the performance of the specimen becomes irregular, as the yield point is passed in steel or as such phenomena as bond slip begin in concrete; this danger zone precedes the fatal event, failure.

In a strongly paradoxical sense we may say that the engineer is often not especially interested in what does happen in the structure. We may plan an analysis to tell us what *does* happen in a particular case; such an analytical investigation is usually for the purpose of interpreting a test or for the purpose of investigating a failure. More often we plan an analysis to investigate what *may* happen in a structure.

Particularly we may wish to investigate *the probability* of such things happening, for engineers must always ask what rate of insurance they are willing to pay against failure. This whole field of probability of occurrence is inadequately treated in any formal way in present literature. It is, however, a question which must have some investigation in all cases where analysis is to be used as a basis for design. It is at the root of all factor-of-safety determinations.

The element of chance

To throw some further light on this phase of the subject, it may be said that there enters here, in the solution of any problem in structural analysis, a large element of chance, and we can scarcely say that we have analyzed the stress conditions until we have taken account of this element. In many cases it is possible by a purely analytical procedure to show that such variations as are possible in the physical properties of the material can produce only small effects on the final solution. In other cases it can be shown that the uncertainties in the physical properties change the answer very much, and hence that the action of the structure is, within a wide range, a matter of chance.

When we recognize such facts, we cover them by adjusting the factor of safety; the stale joke "factor of ignorance" has been overworked in this connection. But structural analysis is incomplete and may be quite dangerous, which fails to weigh this element of chance. No formal mathematical procedure seems available for doing so, but we can use the crude statistical procedure of varying the constants, to see what effect such variation has on the answer.

The writer tried to do this some years ago in studying the effect of erratic variations of the modulus of elasticity of concrete upon the moments in an arch ring. Various combinations of moduli in different parts of the ring were assumed, analyses made for these combinations, and the resulting data were studied statistically. Much work of this kind remains to be done.

Such studies must cover a pretty wide range of variation to be serviceable. One is tempted to ask how wide this range must be. The problem of maxima and minima where there are many variables is one which the engineer encounters daily. In many such cases the range puts the problem entirely outside the possibility of definite answer by a laboratory, and the too-familiar phrase *"Tests clearly show"* often needs to be considerably modified.

Interpretation of analyses

There is with some a persistent feeling that all stresses are equally important, that every case of overstress indicates danger and every case of understress inefficient design. Yet the fact is that computed stresses have quite different significance in different structures and in different parts of the same structure.

In some indeterminate structures each member or part has its own work to do independently in carrying the load. It may be interfered with by the action of other members—secondary stresses; the objective of the designer is to reduce such interference below a value which experience has shown to be permissible. Beyond this he is not interested in the exact values. All structures that nominally are statically determinate belong in this group.

In a second group of indeterminate structures each part is assisted in its main work of carrying the load by the action of the other parts, but moderate variations in the proportions of one part do not seriously affect the assistance which it gives to another part. Most of the standard forms of indeterminate structures belong to this class. Thus, in a continuous steel truss, small change in the relative size of the members is not very important in determining the maximum stress in any member. In an arch rib of reinforced concrete a change in springing thickness produces only a small effect on the maximum crown moment. Structures of this type can be designed efficiently and economically.

In a third type the members participate in carrying the load, but any change in the load-carrying capacity of one relieves the other immediately of some burden. Sometimes the two parts work together with perfect (or almost perfect) efficiency; elementary examples are parallel beams of the same material and equal depths, double diagonals in truss panels with parallel chords under full-span loading. But in other cases the participating parts cannot work together efficiently; if one part carries more load, the other is not proportionately relieved.

Two schools of thought

This sort of differentiation of structural type may serve to clarify, if not to reconcile, two conflicting viewpoints that have always run through the literature of structural analysis in America. One group of thinkers, of the older school, claims that the indeterminate structure is always inefficient, that the different parts interfere with each other. The other holds that indeterminacy always has special virues, of which economy is one. The older school seems to have erred in grouping all indeterminacy under the inefficient group indicated in the third heading above, but the other school errs equally in neglecting this important classification entirely.

Enthusiastic stress analysts often seem inclined to undiscriminating determination of all possible stress conditions, and there seems a lack of consideration of the relative importance of stress conditions found. It is very important to

distinguish between primary and secondary stresses, however these terms may be defined. To the writer it seems most useful to define primary stress as the stress which is depended upon to carry the load, or in other words the stress that is ordinarily computed as an element in the design. The secondary stress, then, is the additional stress resulting from an incident to the deformation produced by the primary stress, but not depended upon to carry the load.

The important difference here is that in steel the primary stress will in general increase in direct proportion to the load intensity up to rupture. The secondary stress will not increase in direct proportion to loading after the yield point of material is passed. The same distinction in part can be applied—but with less clearness—to structures of reinforced concrete.

The importance of properly interpreting results of stress analysis is clearly indicated in the case of the Vierendeel girder. Claims of economy for this type of structure suggest that the Vierendeel girder has been designed for a total stress equal to the primary stress plus the secondary stress usually allowed in designing riveted trusses. This means that this type has been designed for a primary stress of perhaps 23,000 lb. per sq.in. because triangulated trusses are allowed a principal stress of 18,000 plus a secondary stress of 5,000 lb. per sq.in. The load-carrying capacities of the two structures are presumably not at all the same.

It is important also, as nearly all structural engineers understand, to interpret stress analysis in terms of method of failure. It is immaterial in some cases to the structural designer that a computed stress exceeds a certain prescribed value if there is no conceivable way in which the failure of the material could actually occur. *The interpretation of stress analysis makes absolutely necessary a clear idea of the action of the structural part up to the stage at which rupure is conceivable.*

Probable future developments

Let no one imagine that all of the important work has been done in the analytical field. It would seem more probable that we are just beginning our work. The methods of analysis for internal and localized stress, methods of analysis for slabs, and the treatment of the problem of dynamics of structures are still unsatisfactory.

If one may venture to predict, a great future lies in the development of more flexible tools of analysis, so that we may try to take account of the variations in material and so come to study the whole field, not alone of stress conditions that would exist in ideal material but of stress conditions that might exist in the materials which we actually have.

Again, we are coming slowly but definitely to recognize that many of the most important phenomena connected with structural action are dynamic, and that static pictures are often quite inadequate. The present status of the field of structural dynamics is far from satisfactory. The mathematical theory is perfect except that it works very awkwardly in practical cases. The voice of experience in the field is beginning to be quite emphatic in its statements but continues to be very vague in its terminology; it speaks glibly of rigidity but fails to identify which of several possible meanings of the word is intended.

Here, as elsewhere, popular terminology crudely synthesizes experience, while scientific terminology underlies specialized thinking; the one has breadth, the other definiteness. Such terms as "wobble" or "shudder" represent types of motion, but we are far from correlating them with the definite terminology of mathematical analysis.

We need in this field to know a good deal better what quantities we want to compute, we need more data from laboratory and field as to physical constants to be used in our computations, we need more convenient methods of computation, and we shall need to know what the figures mean after we get them.

Specifically, in the case of buildings, we need to know when and to what extent amplitude of vibration is important and when regularity is important; what allowance should be made for inelastic distortions and for damping. We must know what movements are objectionable, and we need simpler analytical procedures, convenient to use, in terminology that we all can understand. Eventually we are sure to get all this, but the road will be long and the byways many.

Studies of Pipe Friction and Capacity Loss Reported

Two-year investigation by committee of N.E.W.W.A. reveals large differences between predicted and actual loss in capacity of cast-iron pipe—pH values of water are correlated with rate of loss and corrective measures suggested

LARGE financial losses resulting from rapid capacity reduction of water-pipe systems in comparison to the structural life of the pipe are indicated by an exhaustive report of the New England Water Works Association's committee on pipe-line friction coefficients, presented at the Providence convention three weeks ago. The committee found the average actual loss in capacity of tar-coated cast-iron pipe in 30 years of service to be 52 per cent, based on a total of 473 tests in nineteen different systems.

In addition to presenting heretofore unpublished data on friction coefficients of tar-coated cast-iron pipe, with particular reference to the age-coefficient relation for this type of pipe, the report also dealt with the effect of water quality upon rate of capacity loss and with remedial measures for reducing and preventing loss of capacity. The latter include discussions of coefficients of cement and bitumastic-enamel linings, methods of lining pipe in place, corrective treatment of water carried, and pipe cleaning.

The committee of five, appointed in November, 1933, consisted of Elson T. Killam (chairman), Frank A. Barbour, W. W. Brush, Laurence C. Hough and Charles W. Sherman.

The committee endeavored to compile mass data of reasonable precision in view of the widely varying conditions encountered and the many factors that affect the results. This policy of precision applies particularly to the presentation of various "trend curves," or curves expressing the age-coefficient relation. In these trend curves the values of C are plotted against the age of the pipe in years; the results are representative of actual field tests and thereby automatically include all incidental losses due to irregular line or grade, fittings and castings.

The Williams-Hazen formula was used throughout the work for the determination of coefficient values. All values refer to the coefficient C in the expression,

$$v = Cr^{0.63}\, s^{0.54}\, 0.001^{-0.04}$$

Where v = velocity in ft. per sec., r = hydraulic radius in ft., s = hydraulic slope in feet per ft., and C = the Williams-Hazen coefficient.

Since capacity is directly proportional to the value of C, with slope and diameter fixed, a drop in the value of C from 130 to 65 involves a capacity loss of 50 per cent. The Williams-Hazen *predicted* age-coefficient relations—or trends of C—formed a convenient basis for comparison with *actual* trends com-

puted from data submitted to the committee.

Tar-coated cast-iron pipe

The major part of the report deals with tar-coated cast-iron pipe. The summarized results are:

> Upon the basis of the average data it is found that in nineteen cities the average value of *C* after 30 years' service was 64, as compared with a value of 88 predicted in the Williams-Hazen tables. Otherwise expressed, the value of *C* dropped to 88 after only eleven years of service instead of after a predicted period of 30 years. Furthermore, these average figures involve relatively large mains (20.5-in. average diameter). In eight out of ten systems the value of *C* for distribution mains after 30 years' service was less than 50, involving a consequent loss of capacity of 61.6 to 84 per cent, as compared with a predicted loss of 37.5 per cent.

The data on actual loss of capacity in tar-coated cast-iron mains are briefly summarized as follows:

> Supply lines in nine cities showed a loss after 30 years of 37 per cent as compared with a predicted Williams-Hazen loss of 30.8 per cent.
>
> Distribution mains in ten cities showed an actual loss in 30 years of 64 per cent as compared with a Williams-Hazen predicted loss of only 37 per cent.
>
> Average results of 473 tests in nineteen individual systems, including sizes ranging generally from 6 to 48 in. in diameter, with a weighted average size (according to numbers of tests of each size) of 20.5 in., showed an actual loss in 30 years of 51.5 per cent, as compared with a predicted loss of 32.3 per cent for pipe of the same diameter.

The committee concludes from these data that the Williams-Hazen predicted trends are applicable primarily to large mains carrying relatively inactive water and do not represent "average conditions."

Effect of water quality

The wide variation in rate of capacity loss in different systems and the appreciable extent to which this loss progresses in a relatively short time in many systems directed attention to the probable causes of this condition, and in this connection the committee considered the quality of supply. Alkalinity and carbon dioxide have an important effect on rate of capacity loss. Because of the interrelation between these constituents and pH the effect could be measured against the pH value alone. A pronounced relation was indicated by plotting the data from various supplies, of which the pertinent facts are shown in the accompanying tabulation.

Cement-lined pipe coefficients

Reporting on coefficient values of cement-lined pipe, the committee states that, although the data relative to the value of cement lining in maintaining hydraulic capacity are extremely limited in scope, the available information indicated that this type of lining can be credited with a sustained capacity not attainable with tar coating. From the information at hand the average value of *C* for new pipe, 4 to 24 in. in diameter, with cement lining centrifugally applied, is given at 134 based on nominal diameter, and 150 based on actual net diameter.

RELATION OF CAPACITY LOSS TO pH VALUE

(All figures are for tar-coated cast-iron pipe in service for 30 years)

pH Value of Supply	Approx. Average Capacity Loss, Per Cent
8.0	30
7.5	35
7.0	45
6.5	60
6.0	85

Bitumastic enamel lining

Bitumastic enamel lining applied by the centrifugal method was first made in 1931, and no data are available relative to its effectiveness in sustaining hydraulic capacity. The longest service reported was two years, during which time there has been no loss. On tests of 10-, 12- and 20-in. cast-iron pipe and on 30-in. steel pipe it was reported as follows:

> The data indicate that coefficient values for new supply and transmission mains 16 in. in diameter and larger, with bitumastic enamel lining centrifugally applied, may vary from 145 to 160, with an average value of 155 based on nominal diameter. It was also indicated that coefficient values for distribution mains less than 16 in. in diameter, with this type of lining, may vary from 140 to 150, with an average value of 145.

The same material applied by the hand-brush method has been widely used for many years, and visual inspection of large pipe thus lined indicates that at least within periods of sixteen years no apparent deterioration has occurred.

Lining mains in place

Reference is made in one section of the report to available methods of lining mains in place, subsequent to cleaning. Two English methods were mentioned —the Eric process, by which a bitumen lining is deposited electrically, and the Tate process of cement-mortar lining. American developments in this direction include centrifugal placement of a cement lining and the application of hot bitumastic lining in those pipes which are large enough to permit the application to be made.

In addition to the use of protective linings, chemical treatment of the water has been adopted in recent years to reduce capacity loss through corrosion, and mention is made in the report of some of the more important phases of corrective treatment. Lime, sodium hydroxide and soda ash are among the alkalies used to reduce corrosion, but it is essential to maintain the treated water at or very near the saturation point for adequate results. Supersaturation will cause excessive deposits, while undersaturation causes the destruction of the needed protective film. Consideration must also be given to the fact that the pH value at which saturation equilibrium occurs varies with the characteristics of the water treated. According to the committee's conclusions:

> The calcium carbonate or alkalinity of the water and the magnesium content are the most important factors. Saturation occurs at a pH of only 7.2 with an alkalinity of 190 p.p.m., whereas with water containing only 15 p.p.m. alkalinity the pH must be raised to 9.3.

The cleaning of cast-iron mains to restore capacity is an important consideration and:

> Data available to the committee indicate that cleaning will ordinarily restore mains to approximately 85 per cent of their original capacity. The average value of *C* in 24 tests was 39 before cleaning, and 104 after cleaning. If it is assumed that the value of *C* for new pipe was 125, the percentage of original capacity was accordingly 31 per cent before and 83 per cent after cleaning.

Concrete pipe

Available data on concrete pipe indicated an extremely wide range in values of *C*, with individual values as low as 85 and others as high as 152. This wide range was attributed not only to variation in surface texture but also to the relative uniformity of the pipe bore. Tests on concrete pipe after substantial periods of service showed that under normal conditions the initial capacity is well maintained.

The committee recommended the formation of a continuing group to cooperate or form a joint committee with the American Water Works Association to extend the scope of this report. It was also suggested that an endeavor be made to select typical pipe lines representative of the more important classifications of conditions, types and sizes of pipe, such lines to be periodically tested to provide adequate data for the information of the profession.

Organizations Sponsoring Pipe-Joint Research

In an abstract of *Bulletin 87* of the Engineering Experiment Station at Ohio State University, published in our issue of Sept. 26, p. 429, the names of the organizations sponsoring the research were inadvertently omitted.

The sponsors of the bell-and-spigot joint research that was reported in the *Bulletin* are the Sectional Committee on Cast Iron Pipe, the city of Columbus and the Cast Iron Pipe Research Association.

Public Works Conference on Municipal Problems

Sewage, water, municipal wastes, street maintenance, financing, traffic control and airports among subjects covered at Cincinnati meeting last week—Long-range planning held essential to effective public-works programs

IN A THREE-DAY technical program the Public Works Conference, Oct. 14, 15 and 16, at Cincinnati, covered the broad field of interests common to municipal activity. In addition, a city manager of forensic ability painted a thought-provoking picture of the present economic situation as it affects the future of municipal public works, and PWA and WPA key officials from Washington were present to participate in a panel discussion of public-works problems and procedures. The conference was sponsored by the American Society of Municipal Engineers (A.M.E.) and International Association of Public Works Officials (I.A.P.W.O.), which last winter set up a joint secretariat with full-time staff largely financed by the Spelman Foundation.

Public-works philosophy

Describing the existing revolution in public-works philosophy as the result of an unemployment situation which in 1930 was a philanthropic problem but which had now become a huge economic and social program whose financing depended on general taxation, C. A. Dykstra, city manager of Cincinnati, stated that public officials and engineers must acknowledge and accept the responsibility of developing a workable scheme of progress. Two schools of thought are at war. One group insists that unemployment and return to pre-depression normalcy can be accomplished only through renewed and widespread capital-goods investment. The other group, the New Deal advocates, preach a theory of expenditures for restoration of the cycle of consumer-goods turnover. Against this background, said Mr. Dykstra, the question for debate is whether or not public-works investments create national wealth either by increasing property values or through dissemination of social benefits.

The great confusion that now exists in the administration of public works he attributed to a lack of precedent upon which to base a workable program; specific weaknesses in the present system are the insistence on standardized methods of procedure, frequent changes or reversals in policy, and inflexibility of action created through the maintenance of a single central clearing house in Washington. If public-works programs are to be successful, decentralization of administration is necessary through establishment of state or regional offices with sufficient authority to shape and carry out worthwhile plans coordinated with local conditions. Because of a long-time interest in the general idea that public-works programs can stimulate employment in depression periods and since we are now in the midst of such an experiment, Mr. Dykstra holds that we should encourage sound federal projects and methods which lead to improved public service, economy, efficiency and better government administration. And on the other hand, where the projects are unsound, works officials should make themselves heard and felt in opposition. However, he stated, public works undertakings in the future must not be incidental to the relief of industrial maladjustment.

Panel discussion of public works

Novel in its setting and effective in getting over its import was a panel discussion on the federal public-works program. Henry M. Waite asked the questions which were answered by E. W. Clark, PWA executive assistant, Carrington Gill, WPA assistant administrator, Charles M. Reppert and Ezra B. Whitman, consulting engineers, and Clifford Ham, director of field service, American Municipal Association. Mr. Gill outlined the federal program and attempted to dissipate the confusion between PWA and WPA, the former being a works program and the latter relief. Mr. Clark pointed out that PWA is a financing and not a construction or initiating agency. The purpose of the inspection and investigation divisions, he said, is to give the government a double check on expenditures, to insure full returns on the money spent. Mr. Reppert, until recently chief engineer, department of public works, Pittsburgh, outlined the responsibilities of the city works office from initiation of a works program through staffing, planning procedure, supervision, coordination and executive administration. Mr. Ham said that in handling works programs there is need for better coordination between the three levels of government—city, state and federal. The principal evil lies in insufficient decentralization.

Following the more formal addresses, questions covering PWA and WPA rules and regulations as well as questions from the audience were answered by the government officials present. These included for WPA: Perry Fellows, assistant chief engineer; Bruce McClure, director of professional and service projects; David Robinson, executive assistant; Carl Schneider, senior engineer; for PWA: E. H. Foley, Jr., director, legal division; Charles W. Fitch, assistant director, housing division; J. G. Gholston, director, inspection division, and Michael Straus, director of publicity.

The technical sessions of the conference were opened by a series of five-minute discussions of the major characteristics of the public-works field in 1935 and of new practices developed during the year. Thirteen engineers, from various parts of the country, took part. It was generally concluded that municipal governments have passed through the depression years in much better condition than most private businesses but that capital investments and public improvements throughout the country are at their lowest ebb and will not improve for some time. The borrowing capacity of cities, limited through bonded-indebtedness statutes and the tax-resisting attitude of citizens, was held to be the principal factor regulating capital expenditure. Although many of the officials reporting were discouraged and disappointed with PWA activity, several endorsed highly the worthwhile work that is being accomplished. Lack of long-range planning in the past is the principal deterrent to successful prosecution of present public-works projects, it was generally concluded; immediate and continuous comprehensive planning for the future is, therefore, to be commended. The following cities were represented: Newark, N. J.; University City, Mo.; Columbus, Niles and Lorain, Ohio; Oil City and Meadville, Pa.; Niagara Falls and Rochester, N. Y.; Miami, Fla.; Ann Arbor, Mich.; Milwaukee, Wis.; and Aurora, Ill.

Street maintenance

H. H. Krantz, engineer of highways, Cincinnati, spoke on "New Methods and Equipment in Street Maintenance," showing slides of equipment utilized in Cincinnati. Recently a new dustless asphalt plant has been installed. One man operates the batching, and an electric eye controls the pug mill.

For repairing cuts in concrete pavements an old truck has been fitted up with a water tank, an aggregate bin and a low platform at the rear end on which a small mixer is mounted.

Consolidated equipment department

The motor equipment department of Milwaukee was described by E. H. Gerlach, superintendent of garbage collection and disposal. Interdepartmental

use of equipment in Milwaukee aids in keeping the number of pieces of equipment at a minimum for the city as a whole. A higher standard of morale, with better-trained and more efficient operating personnel are also possible through this organization which functions as a large-equipment rental agency. The personnel, headed by a superintendent, comprises 500 employees who maintain about 1,300 pieces of equipment of all descriptions, representing an investment of about $2,000,000. The dispatching office has an accurate and complete card record of each piece of equipment and every operator, from which assignments and location of equipment are speedily made and checked.

Garbage and sewage

Robert B. Brooks, consulting engineer and one of the delegates to the International Congress on Public Cleansing, stated that noxious motor fumes are receiving careful study in many European countries on the basis that they are harmful to health. In France, three cities with narrow crooked streets have laid pipes for the pneumatic removal of street wastes to a central disposal plant. Inlets are 200 ft. apart. Mr. Brooks described in detail the tipping method of garbage disposal by which the wastes are spread on dumps in "finger" lines with the faces narrowed to 20-ft. width and covered 18 to 24 in. deep with earth. This covering seals the material during the fermentation period of six to twelve months, after which the refuse area is "dead" and settles from 10 to 16 per cent. In England he reported the cost of covering as 6 c. per ton, with the areas eventually converted into recreation spots. One of Europe's main advantages over America in matters of public cleansing, in Mr. Brooks' opinion, lies in the fact that secure tenure of office prevails, with the personnel chosen on a basis of technical qualifications.

Combined disposal of sewage sludge and garbage was discussed by Henry W. Taylor, mostly from the standpoint of incineration of garbage with dried digested sludge. Digestion of sludge can be accelerated by heat secured from hot-water coils in the incinerator boilers, and air-drying is hastened by waste stack heat. Auxiliary heat for burning can be obtained from sludge-digester gas.

Mark Owen, Dearborn, Mich., in discussion, stated that fresh or semi-digested sludge is being burned successfully with less than 2 gal. of oil per ton of cake with 65 per cent moisture. Formerly, the sludge-disposal cost was $1.50 per ton, now the cost is $0.70. To avoid odors from the stack, it has been found that temperatures should exceed 1,500 deg. F.

The number of approved methods of sludge disposal that have been developed in the last few years makes it imperative that the designing engineer of sewage plants should carefully analyse all the facts available regarding different processes. This was emphasized in a paper by N. T. Veatch, Jr., consulting engineer, Kansas City, who stated that the enthusiasm attending the adaptation of a certain process to one particular installation must not be construed as acknowlegment of its universal application in all plants. Fundamentally, the best method for the disposal of sludge is the one that will give the lowest cost considering the elements of fixed capital invested as well as operating costs.

Sewage Patents—In appraising the patent situation in sewage treatment, Paul Hansen, of Chicago, indicated that the various patents might broadly be classified in the following groups: 1. Patents that are valid and useful and for which a reasonable royalty is charged; the Imhoff tank was mentioned as an example. 2. Valid and useful patents upon which an unreasonable royalty is demanded; fortunately, there is sufficient latitude in sewage-treatment processes to provide substitutes, and these patents are of no great concern. 3. Patents unexpectedly obtained or affirmed by the courts, which, as a group, cause the greatest confusion among engineers; in this connection the old septic tank suits were mentioned and the recent activated-sludge litigation. The latter patents, most of which expired in 1934, leaving only one which expires in 1937, were believed to be invalid by many engineers because of the well-established claims of the Lawrence Experiment Station in Massachusetts, but the courts held otherwise despite the admission by the patentee that he was not the original inventor. 4. Patents of doubtful validity but for which royalties are asked, although these charges are usually hidden in the sale price; continuous sludge removers might be placed in this category.

The author believes that so far as sewage treatment is concerned, the patent situation is not serious because many of the present claims have or will shortly expire, and the many varieties of treatment processes offer sufficient alternate schemes to avoid difficulties.

Utility regulation

Urging that there should be some common principles upon which electric rate schedules are assessed against the users of electricity, E. D. Gilman, director of the department of public utilities, Cincinnati, described the many forms and varieties of rate structures used throughout the country, stating that these forms are so different in many respects that it is impossible to believe that all have equal merit in their application.

Two fundamental principles, at least, affect the form of rate structure; first, an equitable distribution of gross revenue among consumers (the cost of electricity to different classifications of consumers should approximate the cost of service rendered); second, the form of the structure should be such as to promote the business. If the advantages or disadvantages of various rate forms, as measured by these two principles, can be determined, then a recognized criterion of best practice will be established by which all municipalities may be guided in their relations with privately owned utilities.

City planning

Alfred Bettman, president, American Society of Planning Officials, spoke on "City Planner-City Engineer Relationship," in which he held that there is need for a separation of the planning agency and the administration agency as personified by the city engineer. The planners, he indicated, should have no power over final decision but should review all matters with open-minded consideration. Since the boundary between the two fields is hard to define, the utmost in cooperation is essential.

Population characteristics will and should have much effect on all future public-works activities, according to L. Segoe, city planning consultant, Cincinnati. While population is only one factor to be considered in developing a public-works program, the decreasing rates of growth, redistribution trends and other maladjustments are clearly matters that should be given due weight. As we approach a stable population there will be fewer children and more old people, which condition, he concluded, will require fewer schools but more libraries and parks.

Recent changes in city and regional planning practice were noted as follows by Thomas Buckley, chairman of the committee on the subject. More progress has been made in the last two years than in the previous 20 years due largely to the federal activation which put state planning bodies to work in 46 states. Many projects that sought to take advantage of government financing have been poorly conceived as to form, location and coordination; municipalities have suffered more than the rural areas in this respect. Trends, Mr. Buckley noted, are in the direction of practical or rational type of planning; toward decentralization and better housing, an element largely overlooked in the past; toward more elasticity and better execution and toward the planning of areas larger than cities. Five aspects of planning, definitely in need of improvement, were stated to be: financing, legislation, regulation, plan and administration.

Walter Blucher, executive director, American Society of Planning Officials, made a plea for cooperation between planning commissions, city engineers and public-works officials to avoid duplication of effort and to promote orderly progress. A central agency composed of representatives of these three bodies was suggested to pass on projects in the light

of the need for physical improvements and the relation of such improvements to the future development of the community.

Street lighting and traffic control

Paul Goodell, chairman of the street-lighting committee, indicated continued interest and experimentation with sodium and mercury vapor lights for highways. A visibility device, similar to a smoke tester, with an adjustable interposing screen, has been used in these studies.

Burton W. Marsh, chairman of the street traffic committee, presented a plan of action for engineers who desire to improve traffic-control measures. Some of the suggestions were: Secure the *Manual on Uniform Traffic Control Devices* prepared by the American Association of State Highway Officials and the National Conference on Street and Highway Safety; have national standards adopted; carry out a sign and roadway improvement program following a traffic sign survey; improve existing stop-and-go signals by cutting tree branches obscuring the faces; change routings for through traffic; help physical conditions by cutting back corner curbs and by installing safety zones; conduct an accident analysis; and finally sponsor a comprehensive traffic survey.

The airport construction committee report by Robert S. Hedtler, chairman, reflected a plea for military preparedness through better airports. The basic requirements of the Department of Commerce rating regulations were submitted, and it was indicated that the department would send experts to evaluate conditions in any community and that WPA stood ready to assign labor to build airports on approved sites.

Committee reports

Street Cleaning—The use of citizen-educational campaigns, to instill clean-street consciousness, has been given considerable attention this past year as a means of litter prevention, according to the report of J. S. Flockhart, chairman of the standing committee on street cleaning, who stated that continued curtailment of the street-cleaning appropriations and the increasing quantities of debris occasioned by the number of unemployed on the streets create severe handicaps in efficient cleaning operations. A trend toward mechanization of equipment is noted, although much use is now being made of relief workers for hand-broom cleaning.

In the report of the committee on refuse collection and disposal, headed by Carl Schneider, it was suggested that time and motion study research directed toward routing, handling and other operations would result in major reductions of operating expenses for municipalities who undertake such investigations. Large-scale garbage-grinding operations at St. Louis were described where a new $75,000 plant is now disposing of 600 tons of this material in an 8-hour day at a total cost of 55c. per ton. This plant shreds and pulps garbage for disposal into a trunk sewer that discharges into the Mississippi River; no clogging of the sewer has been observed in eight months' operation, and the identity of the garbage in the sewage is lost within a few hundred feet of the point of discharge. Grease yields in garbage reduction plants have become smaller during the depression years (in one place, 7½ per cent) but the present relatively high price being paid for grease continues to make fair revenue returns. Philadelphia recently added a reduction process to one of its incinerators which not only cuts down plant operation from 24 to 9 hr. but is expected to yield a grease revenue of $16,000 a year.

Water—The report of the committee on waterworks (L. R. Howson, chairman) emphasized progress in water purification. Attention was called to the high price of granular activated carbon as compared with the powdered product. This difference has retarded the use of carbon filter units which have proved so effective at the Chicago water-purification experiment station. Growing interest in surface washing of filters was noted.

Sewage—George B. Gascoigne, chairman of the committee on sewerage and sanitation, presented a comprehensive and well balanced report on the present status of sewage treatment. The report emphasized the continuing importance of trickling filters. Fly control and odor control need further attention. Use of trickling filters in conjunction with aeration and chemical precipitation has possibilities not fully exploited.

Paving Status—In the report of the street paving committee, E. L. Knebes, chairman, indicated the status and trends of asphalt, brick and concrete paving as follows:

In concrete highways division of the pavement into 10-ft. strips is gaining favor. Dowels for spacing have been reduced from 2 and 3 ft. to 1 ft. Expansion joint spacing has been increased to 100-ft. intervals and contraction joints to from 15 to 30 ft. Finishing machines are being used advantageously on the central portion of city streets. Vibrators are replacing spades. Concrete of a given strength is being specified rather than of a fixed mix. Curing for 72 hr. with wet burlap or cotton mats has become standard practice.

For asphalt roads, bases of lean mix (not stronger than 1:3:6) are preferred due to the lower shrinkage factor. Where joints are required, as at intersections, a 4-in. asphalt binder-filled space is recommended. The present trend is to use a maximum amount of asphalt consistent with the minimum stability required. On residential streets surface treatments are popular using ¼ to 1 gal. per square yard, or about as much as can be absorbed in 2 hr., and then following with a seal coat.

Vertical fiber brick pavements are on the increase, 65 per cent of the total shipments being of this type. The development of de-aired brick is promising due to its greater strength and density. An asphalt filler has been almost universally adopted. Relaying and turning over of old brick pavement has proved an excellent relief-work project in which some cities report a salvage value of 80 to 90 per cent.

Specifications—H. F. Clemmer, chairman of the committee of bituminous pavement specifications, submitted a specification on cold-laid asphaltic concrete pavement of the plant-mix type. The brick pavement specification as printed in last year's *Proceedings* was adopted and ordered to letter ballot. Roy L. Phillips is the chairman of this committee.

Organization developments

Honorary memberships were voted by I.A.P.W.O. to J. C. Dawes, England, Dr. A. Schroder, Germany, and Alfred Ballo, Hungary, past and present chairmen of the International Congress for Public Cleansing. The following were elected to office for the coming year: Mark B. Owen, president; J. E. Root, J. S. Flockhart, and F. T. Paul, vice-presidents; E. A. Miller, treasurer; A. M. Anderson, secretary.

Three testimonial awards, made each year to members of the A.M.E. who have a record of continuous service in the same city for more than 25 years, were presented to H. H. Ogden, W. C. Reeder and Joseph Barnard, each of whom has been in the engineering department of the city of Philadelphia for more than 40 years.

The newly elected officers of A.M.E. are as follows: president, George B. Gascoigne; vice-president, Thomas Buckley, Guy Brown and Henry L. Howe; treasurer, Roy L. Phillips; secretary, C. W. S. Sammelman, St. Louis.

The Joint Administration Board is composed of four designated members from each organization operating the joint secretariat. The personnel of the Joint Board is as follows: representing A.M.E. are George B. Gascoigne, Guy Brown, Harrison P. Eddy, Jr., and Charles M. Reppert. Representing I.A.P.W.O. are Mark Owen, J. E. Root, A. E. Roche and William J. Galligan, who was named as chairman of the Joint Board. Donald C. Stone, executive director for the past year, has resigned, and Frank W. Herring, assistant director, was appointed executive director. Essentially all activities of both societies will continue to be centered in Chicago under the aegis of the Public Administration Service along with fourteen other municipal organizations. The joint effort is supported in part by grants from the Spelman fund. A movement is under way by the latter to erect on the campus of the University of Chicago a suitable building to house all of the organizations.

Precast Concrete Cribbing for Small Retaining Wall

WORK incidental to installing and maintaining submerged pipe lines across Burrard Inlet at Vancouver, B. C., made it desirable to provide access from deep water to the shop and storage yard maintained near the city by the Greater Vancouver Water District. The importance of this water access, to facilitate work with diving barges, derrick scows, tow boats and other floating equipment, was such as to warrant excavating a channel 1,800 ft. long to reach the shops. The question of what sort of retaining wall to build at the end of this excavated channel, where floating equipment would be moored, was settled by the selection of reinforced-concrete cribbing as the best type of construction under the circumstances. The considerations that led to this selection, with some notes on design and construction and cost figures, are given in the following.

Because salt water would have access to the retaining wall, which is 128 ft. long and 16 ft. high, the danger of attack by teredos and other marine borers had to be considered; untreated timber would have a short life because of these pests. Creosoted timber, recognized as having a much greater life expectancy, would have cost considerably more.

LABOR COST ANALYSIS

Kind of Labor	Daily Rate (dollars)	Man-hours	Labor Cost for Job
Shovel operator	9.00	68	76.50
Foreman	7.00	473	413.90
Steelman	6.00	175	131.25
Mechanic	5.90	22	16.23
Carpenter	5.81	437½	317.70
Blacksmith	5.50	47	32.31
Timekeeper	5.00	87	54.37
Truck driver	5.00	72	45.01
Mixer operator	4.95	99	61.25
Cement finisher	4.79	194	116.18
Laborer	4.26	2,642½	1,407.14
Truck driver	4.26	225	119.81
" "	4.00	79½	39.75
" "	3.85	31	14.93
Team	8.00	8	8.00
Skilled and common labor cost			2,854.33
Engineering, design and laying out			415.09
Total labor cost			$3,269.42

Comparisons of detailed cost estimates indicated that precast reinforced-concrete cribbing would fit the requirements to best advantage. Accordingly plans were drawn for such a structure, shown in cross-section in the accompanying drawing, and a casting yard was laid out at one end of the wall in a location such that a 250-ft. overhead cableway extending lengthwise over the retaining-wall site also would pass over the casting floor. This made it possible to move the precast units conveniently from the forms to their place in the structure. In general forms were built for one-fifth the number of precast concrete pieces required. Reinforcing steel in the concrete units was kept a minimum of 1½ in. from the outer surfaces.

In the design of the crib the fundamental principle laid down was that the crib should have its base below the limit of movement or erosion. Stability was increased by giving the face a batter of 1 in 12. Timber fenders, 10x10 in., are held in place by stainless-steel bolts because of the short life that would be real-

FIG. 2—CROSS-SECTION of the precast concrete cribbing.

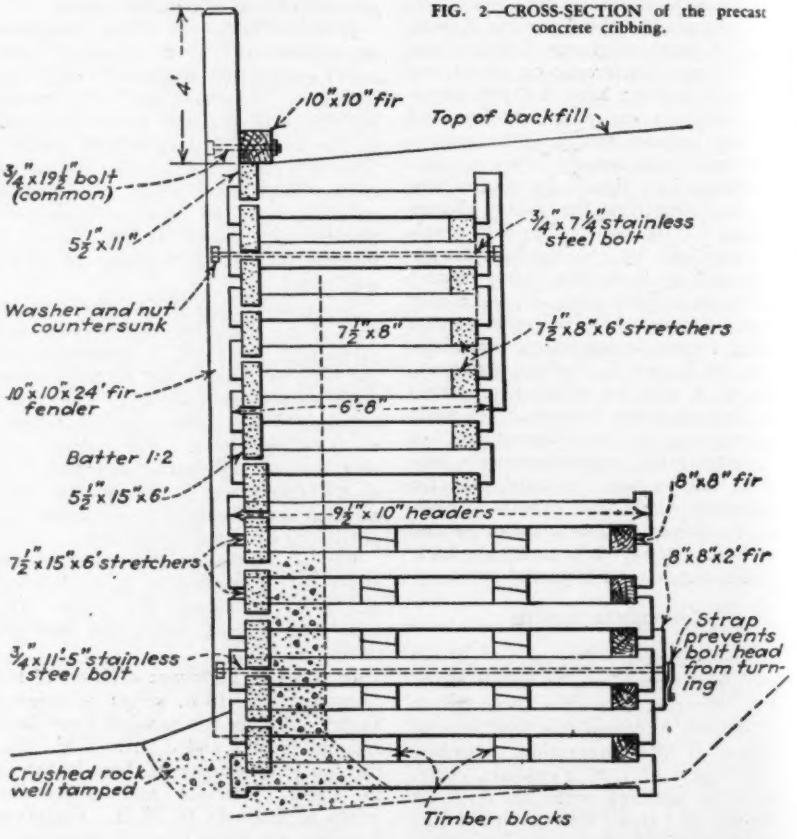
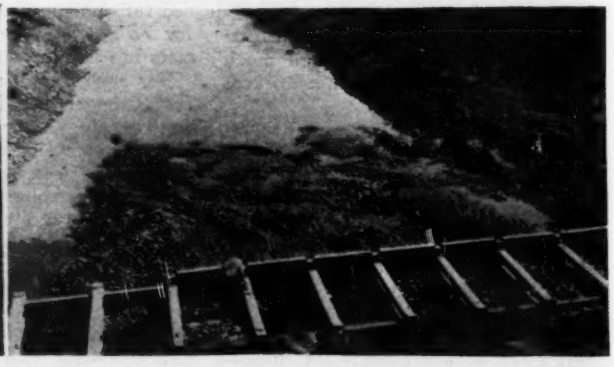


FIG. 1—FACE OF THE CRIB from the channel side. Material piled in the background was used for backfill.

FIG. 3—LOOKING down into the cribs showing the chutes through which fill material was dumped.



ized from ordinary steel exposed to the corrosive action of sea water.

Recognizing that untreated timbers would not have a long life, the bolts that hold them were put in with a view to convenience in replacing the fender. As shown in Fig. 2, the two lower anchor bolts are buried in the fill and their rear ends will not be accessible when renewal of fenders becomes necessary. Accordingly a metal strap was attached to the rear end of these bolts to prevent the bolt head from turning when the nut countersunk in the fender pile is unscrewed.

As the placing of concrete cribbing progressed the cribs were filled in by a grab-bucket, utilizing a spoil bank made when the approach channel was excavated. The backfill was made in two zones; the first 18 in. behind the inner face of the stretcher units was gravel from which all sand had been removed. This was necessary to prevent settlement that would have resulted from the washing out of sand through the spaces between stretchers in the face of the cribbing. Behind this zone of specially graded material the fill was made with the material excavated from the approach channel, mostly sand and gravel. The fill was consolidated with a water jet.

No construction difficulties were encountered and the work was completed as scheduled for a total cost of about $5,000. A cost analysis showed that labor costs totaled $3,270 and material costs $2,175.

COST OF MATERIALS AND EQUIPMENT

Sand, Gravel, Etc.:		
Sand, 32 cu.yd.; Gravel 42 cu.yd.	63.00	
Cement, 434 sacks	290.50	
Calcium chlorite	61.78	
Steel	412.91	
Burlap	57.70	
Stainless steel rods	120.00	
Gas and oil (cement mixer)	30.75	
Gas and oil (donkey)	18.90	
Crushed rock, 62 cu.yd.	63.05	
Lumber for forms and crib	250.39	
Nails	16.89	
Wedges	7.00	$1,392.87
Equipment, Rental or Purchase:		
Concrete mixer (45 days)	$75.00	
Gas shovel (10 days)	250.00	
Hydraulic equipment	180.06	
Cable	29.14	
Donkey	32.68	
Blacksmith	13.97	580.85
Hauling:		
Gasoline	52.50	
Tickets for toll bridge	15.50	68.00
Engineers, Inspectors, Etc.:		
Transportation	132.05	132.05
Miscellaneous	1.81	1.81
Total for job		$2,175.58

Direction

The work was done for the Greater Vancouver Water District under the direction of E. A. Cleveland, chief commissioner. W. H. Powell, from whom the data for the foregoing article were obtained, is engineer for the District.

Stream-Gaging Facilitated by Automatic Radio Transmitters

EXPERIMENTS carried on since 1931 in California have shown the adaptability of automatic radio transmitters to stream-gaging service. Because many stream-gaging stations on major streams are generally remotely located, wire facilities are uneconomic and are not particularly reliable without excessive maintenance. The use of automatic radio stream-gaging stations which transmit flow readings at predetermined intervals, reported by Irvin M. Ingerson, associate hydraulic engineer, California department of public works, has enabled the state engineer's office to keep in nearly constant touch with the great central river system of that state.

Simple, compact mechanism

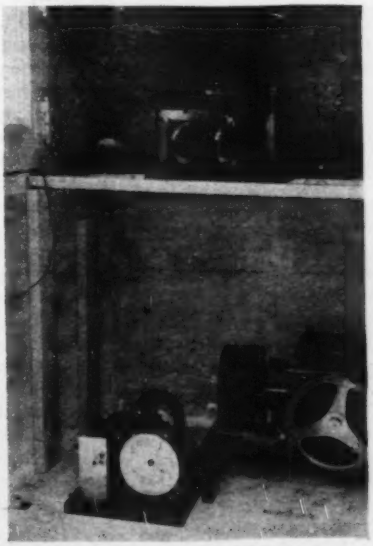
Although radio mechanisms bring into use a highly technical specialty, the automatic transmitting equipment is neither complex nor bulky, the size of the component parts having been designed to fit inside the regulation gage houses.

The transmitter was designer to have minimum power requirement, so that dry batteries could be used. Operating on a wave length of 116 meters with a power output of 1 watt, these stations have a distance range of 100 miles.

Method of transmission

Successful application of the plan was dependent upon the development of an automatic keying device on which Mr. Ingerson has applied for patents. A falling weight geared through a time clock provides a commutation motion that "keys" the radio transmitter, to give signals indicating the gage height of the stream at any specified time. Electrically connected to the clock commutator is the selector or float commutator, the latter being actuated by means of the usual float and counterweight.

Circuits which convert the height of the stream into radio impulses are taken from the rotating selector drums equipped with three sets of ten segments and fingers, thus providing for three significant figures in the gage readings.



AUTOMATIC stream-gaging radio transmitter and key device (on shelf) are controlled by a float and clock set on the floor of gage house.

Depending upon the connections, the height of the stream can be measured to 0.10 or 0.01 ft.

The signal transmitted by the keying device and transmitter consists of a series of short dashes. For example, if the gage height at the time of transmission is 4.62 ft., the signal heard at the receiver would be, first, a series of four dashes, a pause, six dashes, another pause, and then two dashes followed by a long pause. In addition to the gage height, the keying device automatically sends out a call signal identifying the station.

The time-switching arrangements in the keying device are adjustable so that the transmitter can be energized at 2-, 4-, 6-, or 12-hour intervals, and the length of time of each transmission can be varied to run from 5 to 45 min., according to need.

Low-cost operation

Ten installations have been made at critical points on California rivers. Some of these have been operating satisfactorily for over two years and have proved their reliability and accuracy in that time.

The maintenance cost of these stations has been found relatively small. Under normal service a set of dry cells, costing $3, will last two months on a 2-hour schedule and correspondingly longer on schedules of greater intervals. The set of B batteries, costing $10, will last from four to six months.

The value of these radio indicators lies not only in a reduction of administration costs but also in more accurate and frequent information to headquarters than can be obtained in any other way. Their value probably is most appreciated in flood-control work by giving timely warnings when ordinary means of communication are temporarily disrupted.

Current Problems of Civil Engineering Discussed at Birmingham

Fall meeting of American Society of Civil Engineers deals with developments in five branches of the art—Proposed change in membership grading fails to pass—Daniel W. Mead nominated for presidency

TECHNICAL DISCUSSIONS by five of the divisions shared interest with developments in the society's internal affairs at the Birmingham meeting of the American Society of Civil Engineers last week. Sessions were held by the structural, sanitary, construction, highway, and surveying and mapping divisions, all of them substantially attended. A student section conference was also held during the meeting, though unfortunately during a technical session period.

The traditional hospitality of the corn and cotton country was prominently in evidence. It came to its social climax in a brilliant evening of songs by a Negro chorus in the grounds of the Mountain Brook Country Club. On the industrial side it found expression in an all-day tour through the plants of the Tennessee Coal, Iron & Railroad Co. at Ishkooda and Fairfield, major elements of the industries of Alabama's steel metropolis.

Fellow amendment lost

Prominent among the business developments was the canvas of the referendum on a constitutional amendment to set up a new membership classification, in which the titles "Fellow" and "Member" were to replace the present "Member" and "Associate Member." The voting was heavy, reaching a total of about 4,000. The result favored the "Fellow" amendment by 60 to 40, but fell short of the required two-thirds, and the amendment was therefore declared lost. A second amendment, changing a detail of business procedure, was carried.

Daniel W. Mead, of Madison, Wis., was selected by the nominating committee as the official candidate for president. The official nominees for vice-president and director, chosen by district and zone ballots, are: vice-presidents, E. P. Lupfer (Zone 1), H. W. Dennis (Zone 4); directors, C. S. Proctor and J. K. Finch (District 1), C. E. Myers (District 4), Raymond A. Hill (District 11), L. L. Hidinger (District 14), E. P. Arneson (District 15).

Prizes for papers were awarded as follows: Norman medal to D. C. Henny, Croes medal to A. T. Larned and W. S. Merrill, Rowland prize to W. H. Kirkbride, Wellington prize to H. S. Simpson, Collingwood prize to C. M. Stanley.

The Board of Direction, by resolution, reaffirmed its belief in and active support of the civil service and merit systems; Engineering Council is to act on federal problems arising in this field, while the society's local sections will be asked to deal with state and local problems.

Four honorary members were elected by the board: John W. Alvord, John F. Coleman, Mortimer E. Conley, and William J. Wilgus. The board selected Hot Springs, Ark., as the place of the 1936 spring meeting. Four cases of charges of unprofessional conduct were considered.

Economic planning and the TVA

An unforeseen development grew out of a group of addresses that occupied the society's general session and dinner meeting. Following an aggressive criticism of economic planning by Prof. G. W. Dyer, of Vanderbilt University, who asserted that the established American theory of government is to let business direct its own functioning, Arthur E. Morgan, chairman of the Tennessee Valley Authority, introduced his exposition of TVA objectives with the statement that the American theory of government essentially includes the practice of economic planning.

Dr. Morgan said that our life for a century and a half has been directed by the view that no doctrine of government can remain fixed under the varying conditions of existence. In contrast, both the communistic philosophy and the extreme private-initiative philosophy attempt to rest on fixed dictrine; they have not been followed in America's development. As an example of evolution of doctrine he cited the institution of public education, which took over what had been a private business conducted for profit; the criticisms and protests voiced in those days were much like those heard today wherever the public finds it advantageous to carry on an activity previously in private hands. Fire departments were once private enterprises, he said, but the public found it better to operate them under its own management. Toll roads, tax collection and other activities once in private hands were also cited.

As to the possibilities and function of social and economic planning, he said that Americans are not convinced for or against, but insist on making sure in each individual case. The Russian experience is doubtful. Yet much planning is actually done in this country; examples are planning of schools, power-system development and roads. Other examples are found in the field of the TVA—in stream management, in forests, in the effort to preserve and restore soil fertility.

Speaking of river management, Dr. Morgan cited the regulation of the Catawba River by the Duke Power Co. as an excellent example of what can be done. The Tennessee, however, is ten times as big and is concerned with other objectives in addition to power. This is a new enterprise; no river as great has ever been brought under unified control. One of the TVA's problems is to provide continuous inland navigation, of which we have none now except in the Great Lakes; it is important to the South because the handicap of the southern freight-rate plateau is only partly overcome by depressing the wage level; it should find other relief, and a large network of continuous internal navigation will provide it. The policy of developing internal navigation, Dr. Morgan added, was adopted prior to the TVA, under another administration.

Tennessee River planning and development, he said, are experiments in social and economic planning. He explained in similar manner the importance of planned forest conservation and planned restoration of soil fertility. As to the latter he said that our civilization will be transient if we neglect the land, as was done in Greece, Spain and parts of China.

Fitzgerald Hall, president of the Nashville, Chattanooga & St. Louis Ry., sketched the growth of railroad transportation in the South and the present depressed state of the railroad business. Most of the serious problems of the railroads are due to the ineptitude of the federal government, he said, adding, however, that so long as the railroads had a monoply they got along fairly well; the motor vehicle and the airplane have changed the situation. He saw little hope in lighter, faster and more frequent trains. On the other hand engineering accomplishments have done much to prevent greater losses; cross-tie creosoting saves the railroads from 50 to 120 millions a year, according to different estimates, and rail and track improvements in the last 15 years have cut maintenance expenditures by one-half, or more than $350,000,000.

Large industrial growth of the South was forecast by E. A. Yates, vice-president of the Commonwealth and Southern Corp., in an address on "The Industrial Development of the Southeast." Its natural and human advan-

tages, its mineral, power and other resources, were detailed as the basis for the forecast.

Developments in sewage treatment

In the session of the Sanitary Division, experiments to improve the operation of Atlanta's 22-year-old Intrenchment Creek sewage disposal plant were described by M. T. Singleton, consulting engineer, and G. R. Firth, chemist in charge of the experimental plant. They included introduction of chemical precipitation by chlorinated copperas between Imhoff tanks and trickling filters; the flocculators and settling tanks were equipped with a Laughlin magnetite filter. The sewage handled at the plant is mainly residential. The results to date indicate the presedimentation is not particularly advantageous, that carbon dioxide is an effective means of adjusting alkalinity, and that the efficiency of the trickling filters is increased by small amounts of iron introduced by the chemical treatment. The carbon dioxide was produced by burning digester gases to heat the digesters and passing the gas through the sewage. W. A. Hansell, assistant chief of construction of Atlanta, added to the detail of the experimental work in a discussion, indicating that small amounts of copperas improve the operation of the filters and reduce the filter area required.

A brief illustrated outline of the layout of the Shades Valley treatment plant, newest unit of the Birmingham system, was given by H. H. Hendon, sanitary engineer of Jefferson County. Large proportions of industrial waste reach this plant, and the composition of the sewage is highly variable. For this reason sedimentation is flexibly combined with chemical treatment by chlorinated copperas. The plant is so arranged and valved that one tank may be used either for pre-sedimentation, the chemical treatment and final sedimentation following, or in parallel with the other tank for final sedimentation. Two-stage digestion of the sludge follows sedimentation; the digested sludge is dried on open beds and wasted.

In its effect on quality of effluent, this two-stage digestion was reported to be seven times as effective as single-stage digestion at the Ensley plant. The average chemical consumption was given as 450 lb. ferrous sulphate and 60 lb. chlorine per million gallons, costing $5.17. Return of chemical sludge to the raw sewage has been found to reduce turbidity, suspended solids and oxygen demand of the sewage.

Dams and malaria control

What must be done toward controlling malaria-carrying mosquitos in building and operating reservoirs in the South was discussed in considerable detail by W. G. Stromquist, sanitary engineer of the Tennessee Valley Authority. The malaria problem in connection with dams is not as well recognized by engineers as it should be, he said. Special studies and control measures were necessary in connection with Norris and Wheeler reservoirs as moderate to high malaria rates prevail along most of the Tennessee River. A survey of the Wheeler reservoir area last fall showed 27 per cent of the population affected with malaria in the rural areas, but only one-third as many in the towns.

After a review of the history of malaria control in the United States up to the present, in the course of which the malaria death rate in Alabama decreased from 22.5 per hundred thousand in 1917 to 9.8 in 1933, Mr. Stromquist turned to the malaria hazard introduced by impounded waters. The mosquito *anopheles quadrimaculatus*, which is the important malaria bearer, breeds in shallow ponded water. Constant water level, collection of fine floating debris, growth of aquatic vegetation, absence of wave action and absence of natural enemies of the larvae are factors that favor mosquito production. In constructing a reservoir it is important to clear the ground so as to create a clean water surface and clean shore region, to drain areas that would pocket water when the pool is lowered, and to stock the reservoir with the top-feeding minnow (*Gambusia affinis*). As to operation of reservoirs, a series of experiments at Wilson reservoir showed that the most effective control was obtained from varying the water level. Fluctuation both seasonal and periodic (at weekly or ten-day intervals) is desirable.

> This fluctuation tends to discourage rank growth of aquatic vegetation; anopheles larvae are stranded and die or are carried into open water, where they are more exposed to their natural enemies. With fluctuation, larvicidal measures are reduced, and in some cases may even be eliminated, with consequent reduction of cost. Without fluctuation, control by larvicides will be extremely expensive or even impossible.
>
> The construction schedule must be so planned that water is not impounded during the mosquito-breeding months, for with the water rising slowly through uncleared areas excessive production will result, in spite of strenuous larvicidal measures, as was experienced on Lake Martin and Lake Wilson Alabama. The optimum time of impounding is in fall or winter, so that there will be time for flotage to collect and become stranded on the shore.

In Norris reservoir, which will have a maximum drawdown of 58 ft., all trees and brush were removed from El. 1020 (full pool level) to El. 940. Marginal clearing will be done later. In Wheeler reservoir the entire area below gate crest level (556) is being cleared, and marginal clearing is being done up to 25 ft. width.

Experiments with dusting the shallow shore strip of a reservoir with Paris green by airplane have given promising results. However, fluctuation of water level by 1 ft. height at about weekly intervals accomplished a far greater reduction in mosquito production than either oiling or Paris green dusting, according to observations at Wilson and Norris reservoirs in 1934 and 1935. When conditions at Wilson limited the fluctuation to 6 in., the mosquito production increased so much that heavy application of larvicides became necessary. Again, when the Wilson pool had to be kept constant during last summer to maintain barge navigation to the Wheeler work just above, "effective mosquito control was not established until vegetation was removed from 30 mi, of shore line to make possible effective application of larvicides; the lack of fluctuation more than doubled the cost of malaria control during the season."

Because of the importance of fluctuation, the TVA staff has worked out operating schedules for the group of reservoirs, to accomplish regular fluctuation of water level in the several pools; for this purpose load is to be transferred from one dam to another according to a prescribed program. The schedules show that it is possible to accomplish the desired fluctuation both in times of full-capacity power generation and in the time of lowest recorded flow (week ending Aug. 26, 1935; 4070 sec.-ft. at Florence, Ala.).

Supplementing the paper a representative of the Alabama Board of Health emphasized the necessity of making malaria control integral with the engineering and construction planning of roads, canals, reservoirs and similar works. Ponded water and decaying timber in the water must be combated. Replying to a question, Mr. Stromquist stated that larvicides are not harmful to fish life if properly used.

Utilizing aerial survey methods

Original and effective applications of aerial photographic survey methods were outlined in two papers on reconnaissance and land-purchase property surveys.

N. R. McKay outlined the procedure in locating a 1250-mi. gas transmission line from the Monroe and Richland fields, in Louisiana, to markets in Mississippi, Alabama and Georgia six years ago. Great speed was essential, as the first 100 mi. of pipe had to be laid in 4 mo., and for this reason the aerial photograph method was adopted.

The flights were made at a height of 10,000 ft., at 85 m.p.h. A 10-in-focus camera was used; 7x9 films (100 per roll) were exposed 15 to 20 sec. apart, with overlap 60 per cent longitudinally and 30 per cent transversely. Weather difficulties caused a 5-day photographing job (300 sq.mi. mosaic per day) to occupy three weeks. Ground markers were L-shaped strips of white cloth 60x30 ft., oriented north and east.

On the pictures, of scale about 1,000

ft. per in., an office location was made; copies were furnished to abstractors, right-of-way lawyers, and field survey parties, and were also used in showing bidders over the ilne ahead of the ground surveys. The location was generally straight between control points in flat country, but in hill country followed ridges, which were traced out on the photographs by stereoscope. The office location was transferred from the photographs to the ground, checked by inspection, and entered on the strip maps.

Advantages of the aerial method were: it was rapid, gave quick location (the first survey usually gave the final location), allowed several survey parties to work simultaneously, made the tie-in to corners easy, and allowed the right-of-way men to start without waiting for maps.

Even more extensive application of aerial mapping to property surveys is being practiced in the surveys of the Tennessee Valley Authority, begun in 1933. Ned H. Sayford, chief of the TVA's engineering service division, described the methods and results. Many thousand tracts of land must be acquired for reservoir use, but land records were found hopelessly inadequate. To meet the need for property surveys three methods were used; for city property, tape and transit; for acreage of moderate value, stadia planetable work to a scale of 1 in. = 100 ft.; for general farm property, mapping from aerial photographs.

In this latter procedure, single-lens air photographs substantially free from tilt, with scale determined from ground control points and enlarged to 1 in. = 500 ft. at the mean elevation of the tract, are sent into the field for use as planetable sheets. Identifiable corners and lines are checked, and unidentifiable corners are established by planetable traverse from identified positions, with due allowance for relief displacement. Lines missing on the ground are reestablished by conventional methods. The revised sheets are transferred to maps in the office, tied into the reservoir control traverse. From this map information deed descriptions of all tracts are prepared, metes-and-bounds data being scaled from the map and the acreage determined by planimeter.

Test of the results by transit-and-tape boundary surveys has shown the median error in tracts of more than 10 acres to be about 1 per cent, and the maximum error about 4 per cent. The aggregate of all test surveys, several thousand acres, showed an overall error of a small fraction of 1 per cent. More than 400,000 acres has been surveyed by this method, at a cost less than one-third the ground-survey cost.

Subsequently, the outside boundary of the acquired area is fixed by transit-and-tape traverse tied to the basic control, and all angle points are marked by concrete posts with bronze discs.

According to George D. Whitmore, chief of the TVA survey section, practically no protests against the results of these surveys have come from property owners who had had recent accurate surveys made; generally protests came from owners who were misled by old, inaccurate surveys as to the size of their holdings. Major T. P. Pendleton called attention to the further possibility of using the aerial photographs for determination of contours, which would result in topographic maps better than those now generally available.

Geodetic control

Operations of geodetic type were dealt with by J. C. Carpenter, of the U. S. Bureau of Public Roads, who advocated making highway surveys of permanent value through geodetic control, and Prof. J. A. C. Callan, of Alabama Polytechnic Institute, who reviewed the problems and accomplishments in the CWA and subsequent emergency control-survey work done under the program of the U. S. Coast & Geodetic Survey.

According to Prof. Callan, 273 engineers have been employed in the Alabama control survey work. A large mileage of precise traverse and level line has been run and monuments have been set, which for the first time puts points of geodetically established position within reach of most engineering operations. Great difficulties had to be overcome in obtaining instruments, equipment and transportation, in organizing efficient parties, and in developing methods suited to quick application. However, until the end of the CWA the system worked well, while under the later relief administration, when employment was confined to the relief roll, the difficulties became serious. A woman relief director determined the minimum budgetary deficiency of the person on relief, while the works director fixed the person's grade of employment and his rate per day; the average man worked about half a month to earn his assigned budgetary deficiency. Professor Callan stated that "men with large families and no education were usually paid the highest amounts while educated people on relief were reduced to abject poverty. It proved too much of a task to work the men effectively under these conditions."

In these control surveys, geographical positions are determined on a plane coordinate system represented by the radial projection of true Clarke's spheroid positions upon a cylinder with E-W axis whose surface intersects the spheroid on two meridians near the outer edges of the state or strip to which the projection is applied. Under this "Transverse Mercator" system, worked out for all the states by the Geodetic Survey, Alabama has two separate projections, centered on meridians 85°50′ and 87°30′ respectively.

According to Mr. Carpenter, each year about $12,000,000 is spent on highway surveys and plans, and this expenditure is lost after its first use. Believing that much permanent value can be saved from these surveys by tying them into a geodetic control network, the Texas highway department is working out a trial project utilizing geodetic control; this survey extends from Riviera to Raymondsville, across Kenedy County. The experiences in this work will be used to formulate instructions for other survey projects.

Relatively little additional work is required to extend normal highway surveys to include geodetic control, according to a statement in discussion by T. W. Bailey, who reported the experience in actual field trial. Mason Johnson suggested more frequent tie-ins of the precise traverses of the Coast & Geodetic Survey to definite highway points. Prof. N. E. Wolfard emphasized the necessity of adequate monumenting and reference filing of survey data to make the geodetic control surveys of permanent value.

Highway and construction divisions

In a joint session of the highway and construction divisions the subjects of discussion were low-cost road construction, stabilization of subgrade soils, and construction features of two large current projects—Lake Okeechobee flood protection and Norris Dam.

Frank W. Webster traced the development work of the Tennessee highway department since its establishment in 1915. Eight years of preliminary operations followed in 1923 by experimental work on types of construction and best maintenance methods led up to a 2,500-mile construction and reconstruction program in 1924. Dust trouble became serious soon afterward, however, and bituminous surface-treatment methods had to be woorked out to cope with the dust problem and to provide a wear-resisting surface at low cost. Thin road-mix surfaces were developed, and under traffic less than 1,000 vehicles per day they have proved satisfactory.

C. A. Hogentogler, of the U. S. Bureau of Public Roads, presented in brief abstract a comprehensive monograph on stabilization of bases. Mixture gradation, use of admixtures, and compaction are available means. Electrolytic or wetting phenomena appear to play a part in the action of some materials.

Col. Earl I. Brown, U. S. Engineer Corps, summarized the physical condition of the Everglades region, the flood devastation of 1926 and 1928, the levee project subsequently undertaken under Congressional appropriation, and some phases of the construction methods, including the successful development of hydraulic filling. The history of attempts to regulate Lake Okeechobee, with its 730 sq.mi. area of shallow water, its inflow from 4,200 sq.mi. with mean rainfall of 45 to 60 in., and its lack of any outlet except overflow along the southerly rim of the lake into the Everglades swamp, go back to 1881.

The Everglades Drainage District, a state body, from 1910 to 1929 built a number of outlets, partly to drain off the lake's excess inflow and partly to provide water for irrigating land in the Everglades, but when its uncompleted work was proved by the hurricane flood of 1926 and later experience to provide insufficient protection, agitation for federal construction of a leve was begun, as it was recognized that no adequate protective system could be built on local-assessment financing.

Under the federal project, some 65 miles of high levee has been built along the southerly half of the lake shore, with spillways, drainage culverts and hurricane gates. Both bucket and hydraulic filling methods have been used.

Describing leading features of Norris Dam construction, Ross White, construction superintendent of the TVA, stressed a number of instructive facts and experiences.

The main supply road, a 10:8:10-in. concrete slab pavement 22 ft. wide extending from Coal Creek railroad station to the dam site, had to be built and put in service in the shortest possible time (actually 69 working days). For this reason the fills were rolled in thin layers. Although the road has for two years carried extremely heavy loads and dense traffic, only one 10-ft. square of the pavement slab shows settlement.

The foundation rock of the dam, while sound and generally massive, contained a number of clay-filled seams. These were grouted with cement after washing out the soft material in the seams by water pumped into alternate grout holes. Visual inspection of the results from core-drilled exploration holes 36 in. in diameter showed that the process was effective.

Sand for concrete had to be produced by crushing the local dolomite rock; hammer mills were adopted for the final crushing after trying various machines. "The difference in character of the sand produced from the same rock by different machines was startling," Mr. White stated; "grain or particle shape was affected even more than grain size. Much of the success of the concreting operations at Norris is attributable to the happy solution of the sad problem." The concrete generally was mixed for 1-in. slump, and was moved to place successfully by aid of internal vibrators, speeded up to 4,500 r.p.m. Three two-man machines were able to handle 90 cu.yd. per hour.

The 33-hr. week adopted for labor at Norris, with four 5½-hr. shifts per day (supervisory shifts overlapping the labor shifts) gave reasonable efficiency, Mr. White stated, but "TVA experience indicates that short-hour multiple-shift operation adds materially to the difficulty of supervision and direction."

Highway bridge progress

Following an interesting moving-picture description of the New Orleans bridge construction in a paper by Harry J. Engel, with special attention to the deep open-dredged pier work (see *ENR*, May 10, 1934, p. 589), a timely statement of recent progress in highway bridge design was given by H. H. Houk, bridge engineer of the Alabama highway department.

Millions have been spent needlessly on highway bridges through injudicious design, Mr. Houk asserted. Light loadings and narrow widths, often used against the engineer's better judgment, were a common mistake and sites were selected by precedent of horse-and-buggy days, without regard to the requirement of producing the best and most economical highway. In recent years practice has changed, however. Skew designs are common now; curved alignment and vertical curves are used freely. Thought is given to bridge obsolescence, and often to the desirability of a short life. Where grade, load-capacity or width may have to be changed, the bridge is designed for easy remodeling.

With these changes in view came also attention to appearance, and artistic development of bridges is well established practice. "Next to satisfying the demands of traffic during its useful life, the function of a bridge is to present a pleasing appearance. Unless it does this, the engineer has failed in his responsibility to our profession, his obligation to the community and his duty to our civilization."

Theory has been developed, design methods have been improved, and specifications have been modernized, Mr. Houk said. However, he criticized the practice of setting up definite rules-of-thumb for the design of details not governed by known design principles, on the ground that such rules destroy the young engineer's resourcefulness. Continuous bridges and other indeterminate forms properly find frequent use today, whereas formerly they were avoided. Detailing has improved. The use of standard plans has been largely abandoned.

Standard roadway widths should not generally be used, in the author's opinion; "short bridges should have a roadway wider than their pavement approaches, and on the open road the roadway should be the full width of the shoulders."

Among other phases of highway bridge design the paper discussed floors, the use of concrete slab on treated timber bents in Alabama as early as 1924, the gain of strength from encasement of beams, increased lightness of modern reinforced-concrete piers, shortcomings of abutment design, and railings. He advocated low railings, holding that the current requirement of 3 ft. above sidewalk is still too high.

W. N. Woodbury, of the Virginia Bridge & Iron Co., described the plate-steel deck construction of the Bessemer, Ala., high school stadium. The floor is without rivets; its joints are welded for watertightness, but each sheet or step is strong enough to carry its load without dependence on the welding, as shown by full-size test.

The floor is in steps 26 in. wide, with rise varying from 8 in. at the bottom of the stadium slope to 11 in. at the top; a 3/16-in. plate 34 to 37 in. wide, bent to form a riser and the tread above, and 15 ft. long between stringer supports, forms a construction unit. Angle-shaped lugs welded to each plate at the horizontail joints lock the units together. In full-load test a single unit was loaded with bags of rivets to more than 200 lb. per sq.ft. without distress or objectionable deflection; a concentrated load of 240 lb. on the tread produced only 1/16 in. deflection. The floor construction has been patented.

It was announced at the session of the Structural Division that the division's bridge floor committee will submit a report in the form of a paper at the society's January meeting. Two other committees are expected to report at the Pittsburgh meeting next fall, one on the subject of stress theories and fatigue, the other on alloy steels.

Intensity of Rains Recorded by Agriculture Department

IN RECOGNITION of the need for accurate records of the intensity and frequency of rainstorms in various localities, the Bureau of Agricultural Engineering, U. S. Department of Agriculture, has made available a new publication entitled "Miscellaneous Publication No. 204, Rainfall Intensity-Frequency Data." The new booklet should be of special interest to those engaged in building farm terraces, drainage works, culverts and other engineering projects designed to care for storm runoff.

Information on rainfall intensity, covering periods of 10 to 50 years, has been correlated and compiled from records taken at each of the 206 Weather Bureau rainfall stations, by D. L. Yarnell. The records are believed to be sufficient for predicting with reasonable accuracy the average period of recurrence of intense precipitations in any part of the country.

From records of excessive short-time precipitations, tables showing the short-interval record of the most intense storm and the maximum short-period precipitations for each station have been prepared. Charts showing maximum precipitations in periods of 5 minutes to 2 hours that may be expected to occur with average frequencies of 2 to 100 years, and similar charts showing the maximum 4-hour to 24-hour precipitations of 5-year to 100-year frequencies, were also prepared. The analyses are to furnish a basis for computing required capacities for drainage systems so that they may be designed to carry their maximum probable capacities.

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October 24, 1935

Far Short of the Mark

A FEW WEEKS AGO the money available for PWA projects was cut from the $900,000,000 set provisionally by Congress to a little over $300,000,000 and the balance was assigned by the Allotment Board to swell the funds available for WPA projects because PWA projects were too slow in creating employment. The WPA, according to its own estimates, was going to have 3,500,000 men employed by Nov. 1, while PWA could not be expected to reach its peak of employment until next year. Now that the first of November is but a few days away the country finds that WPA is more than 2,000,000 short of reaching its objective, based on the most optimistic estimates. On the other hand the PWA staff has examined 3,715 of the 3,956 projects for which allotments have been made tentatively and has sent out loan and grant agreements to municipalities covering 2,700 projects. Thus, its objective of having all its projects under contract by Dec. 15 stands a good chance of being attained. Such being the case it seems obvious that, had the PWA program been raised to the limit, useful employment could have been found for a very large number of people about as quickly as under the WPA program—and to much better purpose.

Will Codes Return?

A SIGNIFICANT STEP was taken by the President in assigning George L. Berry to the task of coordinating NRA efforts under last summer's extension act. Major Berry's unique position as representative of both workers and employers—he is president of a printers' union and at the same time himself a large employing printer—and the fact that he has earned the confidence of both groups through his fair and farsighted handling of labor-relation problems, equip him ideally for the enterprise of salvaging the wreck of the code idea. Further, his exceptionally able work in the NRA, where aside from other things he was largely responsible for making possible the construction code, has given proof of his broad understanding of industry's problems. For these reasons the report that he may shortly assemble a new code conference of industry and workers to pave the way to a reborn code system is important news. Future codes will undoubtedly be voluntary, which means that the spirit of despotic government created by the old NRA must be replaced by true industrial cooperation. If it proves that this can be accomplished, a fundamental question remains to be answered: whether the restrictive effect on competition that codes are bound to exert is desirable or harmful. It was concluded by the Brookings Institute, after exhaustive study of production and consumption in their relation to capital formation and distribution, that competition is an indispensable means of keeping prices adjusted to increased productive efficiency, that only by this means can consumption be kept in pace with production, and that artificial control of competition within industry has interfered harmfully with this adjustment. If this conclusion is upheld, code agreements may prove to be backward steps in economic development. The problem before Major Berry and the new NRA, then, is not limited to the psychological difficulty of bringing about agreement on codes but includes the fundamental task of determining whether and how the virtues of free competition can be preserved.

A Valuable New Tool

SINCE A YEAR AGO, when the first move was made to join the activities of the societies representing city engineers and public-works officials, respectively, experience has brought an answer to many of the questions that surrounded the wisdom of the move. It was plain without this proof, of course, that the functions of planning and constructing works and of operating them in normal public service—the respective fields of city engineer and of works official—are interdependent; but the year's experience has now demonstrated that these two groups of men can find fruitful common ground in a joint organization. The pooling of interests of the American Society of Municipal Engineers and the International Association of Public Works Officials in a joint secretarial office has brought distinct gains. Close contact of the new office with PWA and WPA activities proved to be mutually helpful, for the federal agencies often were enabled to reach city officials with important information days earlier than would otherwise have been possible, and on the other hand prompt transmission of interpretations saved the cities much loss of time. The establishment of a well-ordered headquarters in Chicago alongside those of related national organizations, with access to an ample reference library and the services of a Washington correspondent, represented another gain, as they made more efficient society service possible. All told, the year's showing suggests that the new public-works institute is a valuable tool in the municipal field, and as such merits support. It holds out the prospect of enabling the city engineer and works official to render better community service and make the citizen's tax dollar more efficient.

Not a Local Hazard

GREAT as is their calamity aspect, the Helena earthquakes of last week may be said to have some constructive value in overthrowing the rooted belief that California alone of all the United States is concerned with the earthquake hazard. The fact is that earthquakes have happened elsewhere at long intervals, and as the Montana case shows they continue to happen. There is sound reason, then, to apply in every part of the country the main teachings learned from California's repeated experiences. It is true that the same earthquake factors need not be used; smaller factors may be adequate in St. Louis or Boston than in Los Angeles, but at least public buildings should include some provision against earthquake hazard. Fortunately modern framework provides the basic elements of the needed resistance, so that no major change of practice is involved; on the other hand, details of walls, copings, parapets, as well as such associated structural elements as tanks and turrets, offer much opportunity for improvement, as in many instances their present construction would prove unsafe against even a light disturbance. Montana has not had the name of an earthquake region, and the reports of building damage indicate that little thought had been given heretofore to the possibility of a shaking. Future construction in that region will probably include some allowance for earth-

quake hazard, and until science is able to say definitely that some regions are proof against earthquake disturbance prudence demands that every region do likewise.

Through Engineering Progress

IN ADDRESSING the American Society of Civil Engineers at Birmingham last week, Fitzgerald Hall, president of the Nashville, Chattanooga & St. Louis Ry., gave credit to engineers for large contributions to railroad efficiency, and expressed the hope that their further help will assist the railroads in overcoming the adverse conditions which confront them today. His words represent a gratifying recognition of the part played by engineering progress in solving the problems of modern civilization, but at the same time they give very definite expression to the continuing responsibility that rests on the profession. Yesterday's progress will do but little to solve the difficulties of today and tomorrow. Only steadily continued research and development can keep pace with the growing problems met on every hand. Individual creative power and initiative will, of course, always be the chief forces that keep up the march of progress, but it is important to keep in mind also the influence of professional group effort, in society, committees and institutions. Whether this influence operates to retard or further progress is the test by which our systems of professional organization will stand or fall.

An Essential Principle

FOR MANY YEARS past it has been an accepted principle among railroad bridge designers that their structures are integral parts of the track roadbed and that a bridge should be so built as to give a train precisely the same operating conditions as the open line. The principle has equal force in the field of highway bridges, as *Engineering News-Record* has many times emphasized. Yet it is so commonly disregarded by highway bridge engineers that it can hardly be said to exist as a practical fact. The restatement of the principle at the Civil Engineers' meeting at Birmingham last week by H. H. Houk, chief engineer of the Alabama highway department, serves to bring it to mind once more.

Road planner and bridge designer alike are concerned in this principle, for both must do their part before it can find effective application. A first necessity, of course, is a suitable road location. Unless the alignment is carried across the bridge in safe and permanent manner, the bridge engineer is given an impossible problem. With this requirement goes the necessity of recognizing that the stream crossing will be a major control point in all revisions, whether change of line or grade, widening, modification of surface, introduction of lane separation, or signaling.

Given these conditions, it becomes the bridge engineer's part to provide in his structure such a profile, width, surface and approach transition that the bridge will not reduce either capacity or safety during its life. Among the matters that he is bound to consider are these: the chance of wheels running on the shoulder, the tendency of some drivers to veer away from truss, girder or curb, the obstruction of visibility, the deflecting effect of entrance roughness or expansion-joint arrangement, and finally the adaptation of the structure to widening or other road revision.

At present thousands of highway bridges throughout the country are points of special hazard to road traffic. Many of them are serious hazards indeed. It should be the goal of the highway bridge profession to remove this reproach to the bridge-building art by concerted, progressive endeavor.

Puzzolanas Command Attention

FROM OUT of the past an old and once-familiar material is rising to complicate the task of the modern user and producer of cement, but perhaps also to confer much-needed benefits. Puzzolana, the name by which the widely variable forms of the material are known, has a long and successful history, beginning with its use as a constituent of Greek and Roman mortars and extending down to present-day European construction. It was used on the Los Angeles Aqueduct and on several western dams 25 years ago and most recently found application in the foundations of the Golden Gate and Bay bridges at San Francisco. Of unquestioned value when used properly, puzzolanic materials therefore command attention at a time when the concrete-making art is experiencing one of its periods of self-analysis as it is today. Puzzolanas also require earnest consideration because there is a growing tendency on the part of cement users to demand them and an increasing number of manufacturers who stand ready to supply them and to promote their use.

What is a puzzolana, how is it used and what will it do? On another page of this issue will be found a well-considered and scholarly discussion of the answers to these questions. For present purposes it may be pointed out that a puzzolana is a "lime-fixer" when used as a constituent of hydrated cement. Usually of siliceous nature, it may be an earth of volcanic or vegetable origin, a burned clay or shale, or an artificial material. Either as a blending agent in cement or as a concrete admixture its purpose is to make concrete less soluble and therefore more durable. There are many concomitant and consequent advantages from decreased solubility, but increased durability covers most of them. And, it may be emphasized, durability is the most sought-after quality of modern concrete.

Unfortunately the mere recognition or even the demonstration of the value of puzzolanas affords little help in actually specifying and using them. Dr. Scripture, in the article referred to above, does not minimize this difficulty. Dozens of materials of different degrees of activity combined with dozens of cements of varying chemical analyses offer the possibility of countless results. Yet study and test may reveal that the results may be grouped in a workable number of classifications. It is to this task of puzzolana selection that cement users and producers must now address themselves.

The user, for his part, has a responsibility neither to close his mind because of the difficulties involved nor to let his enthusiasm for the possibilities lead him to unwise application of puzzolanas. The producers of puzzolan cements and admixtures should be expected to present their claims with adequate technical support and to forego any temptation to let their promotional efforts hark back to the period of patent medicines and witchcraft. A real problem waits to be solved, and if there is a possibility that puzzolanas will aid in producing more durable concrete, all of the knowledge and methods of modern science should be marshaled in their behalf.

CURRENT NEWS

WPA Employment Will Not Reach Goal Set For Nov. 1

(Washington Correspondence)

WITH only 1,310,733 persons employed on the works program, as of Oct. 17, including 582,648 in the CCC, WPA has abandoned hope of reaching its goal of 3,500,000 by Nov. 1. WPA is making a "quick count" of the total number of families and persons eligible for employment on the program. State administrators have been asked for a count, as of Oct. 21, to be in the hands of the statistical offices in their area by Oct. 28.

Harry Hopkins, WPA administrator, is calling also for semi-monthly reports from state administrators on the progress of the entire works program. This report is to be "interesting and understandable to the layman but including information, which may be confidential, as to problems and difficulties. It is to be neither a technical engineering report nor a bare list of statistical material."

Reports to include labor situation

Reminding the state administrators that WPA is charged with the duty of making regular reports to President Roosevelt, Mr. Hopkins suggested that they report how the public is receiving the works program, and whether complete cooperation is being given by local communities and organizations. Regarding the labor situation, they are asked to report whether labor organizations are making complaints and if the machinery for adjusting them is working out satisfactorily. If state administrators have occasion to deal with many organizations of the unemployed, they are instructed to report what their attitude is and whether this attitude is changing.

WPA projects have accounted for employment of only 594,427 persons. Federal projects were credited with 133,658, as of Oct. 17.

Funds actually released for WPA projects up to Oct. 19, totaled $831,800,874 out of allotments of $1,107,374,666 approved by President Roosevelt from a total allocation for WPA of $1,140,000,000. Total allotments for the entire works program amounted to $3,572,726,639 on Oct. 3, of which $2,422,499,105 was for projects of WPA, PWA and federal departments and agencies, and $1,150,227,534 for other purposes. These allotments were divided as follows: $803,000,000 for FERA direct relief, $28,000,000 for Federal Employes Compensation Commission; $100,000,000 allotted to Bureau of Public Roads in fiscal year ended July 1, 1935; $12,000,000 to other bureaus of the Department of Agriculture; $113,000,000 for Resettlement Administration; $91,227,534 for administrative expenses and a $3,000,000 revolving fund for the purchase of materials and supplies. The total amount available for allotment by President Roosevelt at time the Emergency Relief Appropriation Act was passed in April was $4,563,410,000. In addition to the $4,880,000,000 carried by the bill, there was $45,000,000 in other appropriations, raising the total to $4,925,000,000. There were disbursements prior to the enactment of the bill, however, of $292,000,000 to FERA, $60,000,000 to the Farm Credit Administration and $9,590,000 for other purposes.

Army engineer officers, appointed as consulting field engineers of the WPA program received their instructions last week in a 3-day conference with Maj. Gen. E. M. Markham, Chief of Engineers, and Lieut. Col. F. C. Harrington, chief engineer of WPA.

An order by Administrator Hopkins prohibits expenditure of WPA funds to enhance the value of private property. Privately owned airports are an example. Water conservation and irrigation projects are an exception, if the owner dedicates to the general public the right to use the facilities provided by federal funds.

(Washington, Oct. 21, 1935)

BUILDING CUT TO PERMIT MOVING

When Olive St., Los Angeles, Calif., was widened 5 ft., this 13-story Commercial Exchange Building extended 5 ft. over the newly established building line. In order to make the building come within the prescribed line, a section about 5 ft. wide was cut out about 50 ft. back from the face of the building and the front section is to be moved back and rejoined to the other section. It is estimated that this will economize on floor space as well as on money expenditures that would be necessitated by tearing down and rebuilding the facade of the building. The original pier footings were placed on I-beams and steel rollers and will be moved into the new position by a series of jacking operations. The work is being done by the Kress House Moving Company.

U. S. to Build Superstructures Of Pan-American Road Bridges

Construction in the near future of three bridge links in the Pan-American Highway is assured by the signing of agreements between the United States and the governments of Guatemala, Honduras and Panama. These provide that the foundations and approaches "adequate to make the structures usable" will be financed and built by the countries concerned, while the superstructures will be constructed by the United States from a fund of $1,000,000 appropriated by Congress in June, 1934. All three bridges are located on existing highways.

The bridges will span the Tamazula River in Guatamala (600 ft.); the Choluteca River in Honduras (600 ft.); and the Chiriqui River in Panama (350 ft.). Plans will be prepared and construction supervised for the U. S. Bureau of Public Roads, by C. B. McCullough, for the past sixteen years bridge engineer for the Oregon State Highway Department. Mr. McCullough sailed from New York on Oct. 19. The Bureau has established a field office in San Jose, Costa Rica, under John B. Flick, highway engineer. D. Tucker Brown, who had charge of reconnaissance surveys for the Pan-American Highway, is supervising location work and George Curtis Peck is economist in charge of financial arrangements.

Bids for the superstructures of the three bridges will be called for as soon as the planning is completed; probably during the first part of 1936. In the mean time, it is hoped that agreements with Nicaragua and Costa Rica, now in process of negotiation, will be concluded, permitting the construction of additional bridges to those required to make complete the proposed Pan-American Highway which it is hoped will some day extend from South America to Alaska.

Suits Over PWA Power Loans Dismissed to Hasten Appeals

Facilitating an immediate appeal to a higher court, the Supreme Court of the District of Columbia on Oct. 14 dismissed three cases brought by utility companies to block PWA loans to eight cities for municipal power plant construction. These cases now go to the District Court of Appeals, where a similar case brought by the Oklahoma Utilities Co. against a loan to the town of Hominy, Okla., has already been argued and a decision is pending. It is believed that the higher court will hear arguments on some, at least, of the additional cases before handing down a decision.

An order returnable Oct. 23 directing PWA to show cause why a proposed loan and grant of $100,000 to Yorktown, Tex., should not be enjoined was signed Oct. 16 by Chief Justice Wheat of the District of Columbia Supreme Court. The complainant, Central Power & Light Co., claims that an investment of $198,000 would be endangered and that it has a charter to furnish electric power to the community dating to 1965.

Major General Sibert Dies, Was Famous Waterway Engineer

William Luther Sibert, Major General, Corps of Engineers (retired), died at his country home near Bowling Green, Ky., on Oct. 16. Major General Sibert was 75 years of age.

General Sibert attended the University of Alabama and in 1878 entered the U. S. Military Academy, from which he graduated in 1884 and was commissioned in the engineer corps. Up to the time of the Spanish-American War, he was engaged almost exclusively on river and harbor work, being assistant engineer at Cincinnati and then serving as engineer at Bowling Green; assistant engineer for the construction of the Soo Locks and connecting channels of the Great Lakes, and district engineer at Little Rock, Ark., in charge of the construction of locks and dams. In 1899 he went to the Philippines as a captain of engineers and distinguished himself in the field and as chief engineer and general manager of the Manila and Dagupan Railway. On his return from the Philippines he continued his river and harbor work, first at Louisville and then at Pittsburgh. Major General Sibert was largely responsible for the adoption and development of the 9-ft. navigation channel on the Ohio River. In 1907, when a major of engineers, he was one of the three army engineers selected to supervise the construction of the Panama Canal and served as a member of the Isthmian Canal Commission. He was given direct charge of the Atlantic Sector, including the Gatun locks and dam. Under General Sibert's skillful guidance the Atlantic Sector was the first to be completed.

Major General Sibert

In the same year he was granted a leave of absence and went to China to serve as chairman on a commission reporting on internal waterway improvements and flood control. In 1920 General Sibert retired from the army and for the next twelve years was engaged in engineering work. He was made chairman of the Alabama State Docks Commission. In 1928 he became chairman of the Boulder Dam Commission which was to report on the economic and engineering feasibility of Boulder Dam. He served with this commission until 1932.

Grade Crossing And Highway Work Gets Delayed Approval

PRESIDENT ROOSEVELT has at last permitted the Bureau of Public Roads to go ahead on the $400,000,000 highway construction and grade separation program. Announcement of presidential approval of state programs that have waited for months for formal authorization now are coming through daily. The expectation is that there will be no further delay in undertaking a program that was able to get a faltering start only under a provision of the Bureau's regulations (Section 20) which permitted district engineers to undertake construction of projects of a high order of priority without waiting for formal action on the state's detailed program, provided that clearance for such projects was obtained from the state director of the National Emergency Council and the state WPA administrator.

Up to date, and including a number of projects which were started under this section, highway projects totaling $39,413,597 have been approved by district engineers. Contracts have been awarded for 161 of these to cost $8,532,412. Grade crossing projects undertaken on the same basis will cost $18,126,282, of which 41 costing $2,478,864 are under contract in 13 states. The projects given priority will be covered later by the complete state programs approved by the President. The status of highway and grade crossing projects as of Oct. 21 is:

STATUS OF HIGHWAY AND GRADE CROSSING PROJECTS

State	Highway Projects Approved	Highway Projects Contracts Awarded	Grade Crossing Projects Approved	Grade Crossing Projects Contracts Awarded
Alabama	$523,000	$299,024	$1,359,000	$582,327
Arizona	412,000	227,000	.....	.....
Arkansas	2,922,200	449,000	268,000	98,000
California	.....	.....	37,000	.....
Colorado	2,667,000	446,830	236,000	.....
Connecticut	.....	.....	.....	.....
Delaware	.....	.....	.....	.....
District of Columbia	1,003,496	.....	220,000	.....
Florida	46,000	.....	1,084,000	.....
Georgia	.....	.....	.....	.....
Idaho	556,000	115,000	420,000	52,000
Illinois	984,000	.....	67,000	.....
Indiana	870,000	.....	619,000	.....
Iowa	571,000	375,126	693,000	372,112
Kansas	1,266,000	11,887	.....	.....
Kentucky	762,000	.....	.....	.....
Louisiana	729,779	.....	.....	.....
Maine	585,706	.....	.....	.....
Maryland	.....	.....	.....	.....
Massachusetts	.....	.....	1,270,000	.....
Michigan	4,535,000	2,537,266	1,543,050	838,135
Minnesota	414,300	.....	.....	.....
Mississippi	1,191,950	.....	835,450	.....
Missouri	2,073,500	81,186	.....	.....
Montana	1,050,000	.....	723,000	.....
Nebraska	640,000	.....	1,128,000	.....
Nevada	245,000	226,419	153,000	.....
New Hampshire	88,000	15,116	.....	.....
New Jersey	.....	.....	.....	.....
New Mexico	84,000	.....	243,000	.....
New York	2,211,650	1,177,399	.....	.....
North Carolina	205,000	1,579,000	.....	.....
North Dakota	752,200	214,400	50,000	39,400
Ohio	1,921,497	.....	.....	.....
Oklahoma	164,000	71,000	433,000	159,000
Oregon	1,573,669	730,560	1,624,791	33,000
Pennsylvania	.....	.....	.....	.....
Rhode Island	314,000	.....	699,691	.....
South Carolina	1,540,000	179,391	134,000	54,467
South Dakota	387,200	181,900	48,000	.....
Tennessee	502,000	.....	82,000	.....
Texas	2,174,750	476,260	101,000	59,009
Utah	257,000	107,000	162,000	26,000
Vermont	49,000	.....	.....	.....
Virginia	245,500	85,000	.....	.....
Washington	1,042,700	233,048	1,423,300	.....
West Virginia	546,000	.....	.....	.....
Wisconsin	1,307,500	272,600	2,141,000	116,000
Wyoming	.....	.....	428,000	49,423
Totals	$39,413,597	$8,532,412	$18,126,282	$2,478,864

Washington Highlights

By Paul Wooton

Along with other industries construction will have an opportunity soon to say whether or not there is anything in the NRA scheme that it wants to salvage. The plan of George L. Berry, the President's Coordinator for Industrial Cooperation, for a Washington meeting of representatives of industry is being widely supported.

Construction at grade crossings that makes provision for an emergency turn off the road is finding increasing favor among highway engineers, reports reaching Washington show. If separation is not justified a safety factor is introduced by a roadway paralleling the track each way from the highway, so banked as to check the speed of an automobile that may have to make the turn to avoid the rail crossing.

Mounting mortality on highways has revived the question of discouraging high speeds. Among suggestions being considered is that the manufacturers' tax on automobiles be graduated with respect to horsepower.

Recent studies in Washington show that labor's proportion of the road dollar is practically the same on highgrade pavements as it is on dirt roads. In each case the result is within a few mills of 76c. In one case nearly all employment is direct, in the other most of it is indirect. It also was shown that 35c. out of each dollar spent for concrete goes for transportation.

Washington, Oct. 21, 1935.

Frequent Earthquakes Do Much Damage in Western Part of Montana

A LONG series of earthquake shocks extending from Oct. 11 to Oct. 21, with strongest movements on Oct. 11 and Oct. 18, shook the mountain region of western Montana, apparently centering at or near Helena. Chief damage was done in the capital city. The disturbance was felt as far north as the Canadian line, south to northern Wyoming, and west into Idaho.

Damage in Helena was confined to old and weak structures and to minor plaster and partition or wall damage. The general facts of the occurrence are given in the following report of William A. Lamb, District Engineer of the U. S. Geological Survey at Helena:

"The quakes of Oct. 11 and 18 rated 7 and 8, respectively, on the modified Mercalli intensity scale used by the Coast and Geodetic Survey. In comparison, the last disturbance of comparable strength in this region, which occurred July 27, 1925, was of intensity 8. During the week between the two strongest shocks a dozen or more of intensity 4 to 5 occurred and probably 200 or more of intensity 3 or less. The heaviest shock, that of Oct. 18, caused but little damage to well constructed buildings with steel or reinforced concrete frames resting on solid foundations. Some damage resulted from falling plaster and cracked interior walls, and in a few cases brick outside walls were cracked. In general, buildings stood up remarkably well. Much damage was done to an old school building and to commercial buildings that lacked steel or concrete frames; many of these buildings were of poor construction. In addition something like a hundred brick and stone residences of old and poor construction were made uninhabitable. Chimney damage was much more extensive, and probably 200 residences were damaged by falling chimneys. Modern brick and stone residences suffered little loss.

"No damage was done to gas or water lines, but wire services—telegraph, telephone and electric light—were interrupted about an hour. There was no loss from fire or water.

"At least two deaths were caused by the earthquake. The property loss is estimated to exceed $2,000,000. Public order was easily maintained, as the police and local national guard company handled the situation effectively."

Reports from the mines in the Butte-Helena region indicate that the shocks were felt underground, in some cases strongly enough to cause alarm, but no underground damage resulted. F. A. Linforth, assistant chief geologist of the Anaconda Copper Mining Co. at Butte, reports to *Engineering and Mining Journal* that the shock produced no underground disturbances in the Butte mines, adding that "earthquakes are generally not felt in deep mines." F. A. Thompson, president of the Montana School of Mines at Butte, wires the same journal:

"The earthquake was caused by movement along the northwesterly trending fault in the rocks deeply buried beneath the alluvium of Helena valley. The smelter stack at East Helena had the top twenty feet damaged. The Springhill mine 5 mi. south of Helena reports that the shocks were distinctly felt underground and the miners flocked out, but no damage was caused. The Golden Messenger mine, 15 mi. northeast of Helena, felt the shock underground but experienced no damage. At the Comet mine of the Basin Montana Co. at Basin, between Butte and Helena, the shock was distinctly felt as the miners were coming out for lunch but they returned to work after lunch, and the management reports no damage to either mine or mill."

In eastern Idaho, even close to the Montana mine, no disturbance or damage occurred in any of the mines, according to Stanly A. Easton, president of the Bunker Hill and Sullivan Mining & Concentrating Co. of Kellogg, Idaho.

INDUSTRIAL building wrecked by Montana earthquakes. A brick structure, used by the National Biscuit Co., suffered heavy damages in the recent disturbances which shook Helena.

Bids Asked for Foundations Of PWA Housing Projects

Pushing the PWA housing program so as to get work started in time for completion of the units by June, 1937, the Housing Division on Oct. 18 asked for bids on the construction of foundations for 21 additional projects. In this list of projects is included one new development planned for Toledo, Ohio. A new project has also been planned for Schenectady, N. Y., but no call for foundation bids has as yet been made. Foundation bids are being called in an effort to speed up the work while further plans are being developed, and with this latest call of bids all but six of the 46 projects in 33 cities will be in some degree of construction. Five project sites are still under options, and one is being delayed by court action pending the legality of condemnation proceedings (*ENR*, Oct. 17, 1935, p. 548). Sites for the Schenectady and Toledo units have evidently been acquired.

The housing units for which foundation bids have been called and the dates on which bids will be received are:

Birmingham, Ala.	"Smithfield Court"	Nov. 7
Buffalo, N. Y.	"Lang Field"	Nov. 21
Cambridge, Mass.	"Main Street"	Nov. 11
Chicago, Ill.	"Trumbull Park"	Nov. 18
Cincinnati, Ohio	"Basin Housing"	Nov. 20
Detroit, Mich.	"Chandler Park"	Nov. 26
Detroit, Mich.	"Eastside"	Nov. 15
Lexington, Ky.	"Blue Grass Park"	Nov. 6
Memphis, Tenn.	"H-3403"	Nov. 11
Memphis, Tenn.	"H-3401"	Nov. 4
Miami, Fla.	"Sixty-second Street"	Nov. 25
Minneapolis, Minn.	"Summer Field"	Nov. 20
Nashville, Tenn.	"Eighth Avenue"	Nov. 7
Nashville, Tenn.	"Sixteenth Avenue"	Nov. 14
New York, N. Y.	"Williamsburg"	Nov. 29
New York, N. Y.	"Harlem-McCombs"	Nov. 19
Oklahoma City, Okla.	"Rotary Park"	no date given
Philadelphia, Pa.	"Hill-Creek Park"	Nov. 5
Toledo, Ohio	"Belmont Division"	Nov. 19
Wayne, Pa.	"Highland Avenue"	Nov. 5
Washington, D. C.	"Langston Terrace"	Nov. 5

The Toledo, Ohio, Belmont-Division project is estimated to cost about $2,000,000. The units will cover a 16-acre site on Belmont and Division Streets. The new development is for Negro families and is to accommodate 376 families in 3-story apartments and 2-story houses and flats. Bids for the demolition of 230 sub-standard buildings on the site have already been asked.

The seven limited-dividend projects with which the program started 3 years ago are practically complete and all are occupied. Present status of the all-federal program was outlined in *ENR*, Oct. 17, 1935, p. 548.

New York City Building Code Subject of Hearings

Public hearings on the new building code for the City of New York were begun on Oct. 17 and will continue at intervals until Nov. 25. Future hearing by the committee on Buildings of the Board of Aldermen are scheduled as follows: Oct. 23, standpipe systems; Oct. 31, construction; Nov. 18, special occupancy structures; Nov. 21, elevators; and Nov. 25, sprinkle systems. Edward J. Sullivan is chairman of the committee on buildings.

Steel Fabricators Divide Attention Between Economics and Technology

AN air of normalcy, after several hectic depression years and the attendant battle for survival, pervaded the annual convention of the American Institute of Steel Construction in White Sulphur Springs Oct. 16-18. One of the important developments was the return to a prominent place on the program of matters relating to technical developments in the field of structural steel. This change is the more important because a majority of the reports concerned research activities sponsored by the Institute itself. A notable development of the meeting was the decision to raise the basic unit stress from 18,000 to 20,000 lb. per sq.in. Business problems were not slighted, the industry instituting a plan of self-help involving a bid depository and enlarged statistical reports, so that the program as a whole was well balanced and instructive.

The business of fabricating and erecting structural steel is not yet a profitable one, according to a consolidated profit-and-loss statement of the industry. The profit on sales (4 per cent in 1928) declined to a loss of 9½ per cent in 1932, but then rose to a point in 1934 where the 50 companies reporting broke even. Shipments of fabricated steel in 1934 totaled 1,033,629 tons. For the first six months of 1935, 504,215 tons was shipped. The Institute has a total of 174 members now, compared with a high of 223 members in 1928 and a low of 166 members in 1932. The present membership is said to account for 90 per cent of the current tonnage of fabricated structural steel.

Prominent among the new Institute activities is the inauguration of a bid depository in charge of R. T. Brooks, former president of the George A. Just Co., steel fabricators of New York, who assumes the position of executive vice-president of the Institute. The statistical reports of the industry were put on a firmer basis by the appointment of T. H. Hendrix as director of statistics. V. G. Iden was elected secretary and Clyde G. Conley (Mt. Vernon Bridge Co.) was reelected president for the fourth consecutive year. During the year four new district offices were added, with E. N. Adams in charge at Worcester, Mass., C. R. Bloxton at Atlanta, Robert J. Wood at St. Louis, and L. H. Dodd at Dallas.

New unit stress

As a result of many requests to increase the allowable basic stress of the new 60/72,000 lb. steel (33,000 lb. yield point) from 18,000 to 20,000 lb. per sq.in., the specifications committee made a recommendation to the board of directors that this change be made. The directors instructed the committee to proceed with the necessary revisions of the column formula and allowable load tables, to make them applicable to the 20,000 lb. stress. The new values will be published in a new edition of the Institute Manual to be published next year.

Technical activities

The technical research committee, Aubrey Weymouth, chairman, reported that the second progress report on the tests of the steel model of a 55-story wind bent at Ohio State University has been published and is available. This second report covers the design of set-backs and open portals in building frames.

Tests on battledeck floors under concentrated live loads at Lehigh University have progressed to a point where a report has been published, giving the results on two bridge floors with variations in stringer spacing. The second part of the work, now under way, covers testing of two models and one full-size specimen, to give additional information on stresses and deflections.

At the Bureau of Standards in Washington, the Institute is sponsoring an investigation of two large-scale models of the knees of a rigid frame, one with a sharp-angle intrados, the other with an easy curve for the inner flange. Strain-gage readings are being taken at a large number of locations on the web and flanges. The first two speciments are riveted; a welded knee will soon be put under test. H. L. Whittemore, chief, engineering mechanics section, Bureau of Standards, described the investigation to the members. In discussion F. H. Frankland, director of engineering service of the Institute, told of design studies he is making for steel rigid frames hangars. Covering spans of 60, 80, 100, 125 and 150 ft., the hangar designs, made at the request of the Bureau of Air Commerce will be used in the WPA program of airport improvement. They offer the advantage of low overall height thus minimizing induction air currents, and they are easy to erect and economical to maintain. Comparative designs of standard truss roofed hangars indicate that for the 60 ft. span structures the rigid frame requires 14.5 lb. of steel per sq.ft. of floor area and the truss roof 12.1 lb., but that the rigid frame effects a saving of 2.5 sq.ft. of side wall area per sq.ft. of floor and in overall cost of structure is the more economical.

New technical developments allied with the promotion of new markets for structural steel include the publication of a manual on the design and maintenance of steel dams. It was written by Otis E. Hovey, former assistant chief engineer of the American Bridge Co. who was assisted by Mr. Frankland. The manual covers both steel frame dams and earth and rock-fill dams with steel plate facings. Its contents were reviewed in a paper before the convention by Mr. Hovey.

The committee on extended uses of steel which sponsored the steel dam manual also recommended to the Institute and to the rolling mills that the question of corrosion be taken up for serious study. Another suggestion was that the industry set up an agency to review the designs of different builders proposing the use of steel in house construction. A. J. Dyer, Nashville Bridge Co., is chairman of this committee.

The subject of housing and the opportunities for steel in this field was given further consideration in a paper presented by A. C. Shire, chief engineer, Federal Housing Administration. Mr. Shire advanced the opinion that light strip steel, either as frame members or in sheets, offers greater possibilities than structural shapes. Other papers were presented by S. H. Ingberg, of the Bureau of Standards, on fireproofing of structural steel and by H. L. Whittemore, also of the Bureau of Standards, on the opportunities for steel in future construction and on the necessity for greater initiative in promotional research and customer service.

Some of the aspects of welding in structural steel fabricating shops were reviewed by Robert E. Kinkead, consulting engineer, Cleveland, who held up the plate steel fabricator's experience with welding as a warning. In Mr. Kinkead's opinion the plate fabricators lost control of their business when the welding industry sold the fabricator's customers on the advantages of welding. The fabricator then had to adopt the welding industry's recommendations whether they were profitless or not. It will be much better for the structural steel fabricators, said Mr. Kinkead, if they will take the subject of welding in hand aggressively and become authorities themselves on welds and welding.

Industry plan

Acting on the premise that industries can and must do something to establish a basis of business practice devoid of such evils as ignorance of costs and price cutting methods, the Institute embarked upon a plan of cooperative action with active support of the members. The Institute will act as a clearing house and collator of costs, which will be available to all members. It will operate a bid depository, making all bids public immediately after the contract is awarded, and it will continue its reports of tonnage fabricated and shipped. In brief the active support of the steel fabricating industry is solicited in an attempt to throw continuous light on those dark spots in its business methods that have heretofore contributed to unsettled and chaotic conditions.

SOCIETY CALENDAR

INTERNATIONAL ACETYLENE ASSOCIATION, annual meeting, Cleveland, Ohio, November 12-15.

HIGHWAY RESEARCH BOARD, annual meeting, Washington, D. C., December 5-6.

AMERICAN ASSOCIATION OF STATE HIGHWAY OFFICIALS, annual convention, Miami, Fla., December 9-12.

AMERICAN ROAD BUILDERS' ASSOCIATION, annual convention and road show, Cleveland, Ohio, week of January 20, 1936.

NEW JERSEY SECTION, AMERICAN WATER WORKS ASSOCIATION, first general meeting, New Brunswick, N. J., October 30.

WISCONSIN SECTION, AMERICAN WATERWORKS ASSOCIATION, annual meeting, Sheboygan, Wis., November 4-6.

NORTH CAROLINA SECTION, AMERICAN WATER WORKS ASSOCIATION and NORTH CAROLINA SEWAGE WORKS ASSOCIATION, annual joint convention, Durham, N. C., November 4-6.

MISSOURI VALLEY SECTION, AMERICAN WATER WORKS ASSOCIATION, Des Moines, Iowa, November 6-8.

VIRGINIA SECTION AMERICAN WATER WORKS ASSOCIATION and VIRGINIA SEWAGE ASSOCIATION, annual conference, Roanoke, Va., November 7-8.

EXPOSITION OF CHEMICAL INDUSTRIES, fifteenth annual exposition, New York City, December 2-7. Metals and alloys, plastics and plant equipment will be included among the exhibits.

NORTH DAKOTA WATER AND SEWAGE WORKS CONFERENCE at the annual convention held on Sept. 30 elected the following officers: S. P. RAYNOS, president; S. CALVELAGE, vice-president; M. D. HOLLIS, secretary-treasurer.

Obituary

JOHN S. KNEALE, superintendent of sewers, Rockville Center, Long Island, died at his home there on Oct. 16 at the age of 53. Mr. Kneale had been superintendent of sewers for the past seven years.

HARRY L. HORTON, of the Rochester, N. Y., city engineering department for the past 25 years, died there on Oct. 16. He was 49 years old. Mr. Horton, a graduate of the University of Rochester, did much of the design work and supervised the construction of the city's subway.

GOUVERNEUR CADWALADER, retired engineer, died at his home near Fort Washington, Pa., on Oct. 14, at the age of 56. He graduated from the University of Pennsylvania and then became associated with the engineering department of the Pennsylvania R.R. in western Pennsylvania and later joined the firm of Cresson-Morris Co., engineers. He resigned his position as secretary and treasurer of this company in 1918 to serve as a major in the Army and did not return to business after the war.

WILLIAM E. HUNT, consulting architect, died Oct. 13 in Torrington, Conn. Mr. Hunt had practiced in Torrington since 1915 and previously was associated with Wilfred E. Briggs in Waterbury. He designed such important buildings as the Hotel Elton and the Lilley Building in Waterbury; the new Torrington Post Office and a number of Torrington schools and industrial buildings.

CONSTRUCTION STATISTICS FOR THE WEEK

ENGINEERING construction awards at $58,980,000 top the previous high week for this year by 31 per cent and last year's highest week by 5 per cent. State and municipal awards are the highest for any week this year while private awards are only the third highest week and federal awards the sixth highest week. The figures are private, $18,095,000; public, $40,885,000; federal, $12,738,000; state and municipal, $28,147,000. Comparable figures a year ago are: total, $22,625,000; private, $2,897,000; public, $19,728,000; federal, $2,516,000 and state and municipal, $17,212,000.

Highways, earthwork and waterways, and industrial buildings are equally responsible for these broken records. The classified totals are: waterworks, $592,000; sewerage, $1,326,000; bridges, $4,730,000; industrial buildings, $13,343,000; commercial buildings, $3,294,000; public buildings, $7,552,000; streets and roads, $12,755,000; earthwork and waterways, $13,600,000.

The larger contracts include: addition to plant, Contintental Can Co., Chicago, Ill., $1,000,000; fabrication and erection, semi-continuous shear plate mill for Carnegie-Illinois Steel Co., Homestead, Pa., $10,000,000; power plant for Lynn Gas & Elect. Co., Lynn, Mass., $600,000; factory for A. P. W. Paper Co., Albany, N. Y., $500,000; 300 residences for Management Trust Co., Whiting, Ind., $1,500,000; Southwest High School, St. Louis, Mo., $649,000; Franklin K. Lane High School, Jamaica, N. Y., $2,264,000; housing project, Cleveland, O., $3,002,000; concrete sidewalks and curbs along state highways, Mass., day labor, $1,000,000; highways by Oregon, $523,000; by Wisconsin, $521,000; by Michigan, $509,000; by Montana, $955,000; by Texas, $1,673,000 and by New York, $981,000. Large bridges include: Randall's Island Junction for Triborough Bridge, New York, N. Y., $2,144,000; bridges and grade crossing eliminations at Tompkinsville for Staten Island Rapid Transit Ry. Co., N. Y., $558,000. Heavy earthwork, irrigation and waterway awards include: excavation, south bank Cape Cod Canal, Mass., $787,000; sand and aggregate for Fort Peck Dam, Mont., $554,000; portland cement for Grand Coulee Dam, Wash., $5,882,000; power house superstructure and fish ladder, Bonneville Dam, Ore., $1,160,000, and construction Arroyo Seco Channel by WPA labor, Los Angeles, $4,262,000.

New capital for the week includes $7,978,000 in state and municipal bond sales and the balance in WPA allotments and contributions of local sponsors. One factor which is helping to speed up highway awards is the increased volume of Presidential approval of funds previously apportioned for road and grade crossing elimination.

CONTRACTS

(Thousands of Dollars)

	Weekly Average Oct. 1934	Prev. 4 Weeks	Week Oct. 24 1935
Federal Government	$3,034	$4,891	$12,738
State and municipal	15,844	16,600	28,147
Total public	$18,878	$21,491	$40,885
Total private	3,747	9,278	18,095
Week's total	$22,625	$30,769	$58,980

Cumulative to date:
1934..$1,125,029,000 1935..$1,171,343,000

NEW PRODUCTIVE CAPITAL

(Thousands of Dollars)

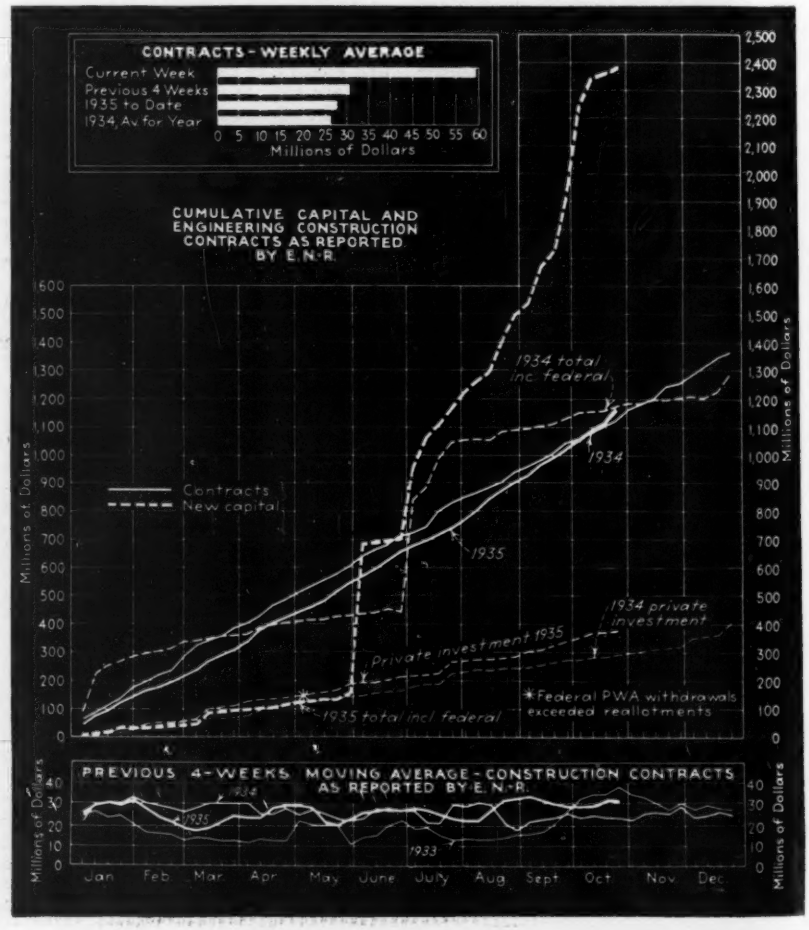
1935	Week Oct. 24	Cumulative
State and municipal	$7,978	$349,081
PWA allotments, S&M	....	751,562
RFC loans, S&M	....	48,180
Corporate issues	....	27,338
PWA private	....	9,086
Local contrib. to WPA	1,842	25,809
Total non-federal	$9,820	$1,211,056
PWA federal	13,608	1,173,425
Total new capital	$23,428	$2,384,481

Cumulative to date:
1934..$1,175,513,000 1935..$2,384,481,000

Note: These figures include private bonds, and stocks sold for productive purposes; state and municipal bonds for construction; PWA loans and grants to states and municipalities, including the special highway funds; PWA private loans, and allotments for federal construction, deficiency act funds. An arbitrary percentage (25%) of the WPA allotments and local contributions to WPA work is included to allow for the capital additions through the Works Progress Administration division of the new program.

INDEX NUMBER

ENR Cost	1913 = 100	1926 = 100	ENR Volume	1913 = 100	1926 = 100
Oct., 1935	195.10	93.82	Sept., 1935	127	56
Sept., 1935	195.10	93.82	Aug., 1935	140	61
Oct., 1934	200.86	95.55	Sept., 1934	94	42
1934(Av.)	198.10	95.23	1934(Av.)	114	50
1933(Av.)	170.18	81.80	1933(Av.)	102	47
1932(Av.)	156.97	75.45	1932(Av.)	127	56


CONTRACTS - WEEKLY AVERAGE
Current Week
Previous 4 Weeks
1935 to Date
1934 Av for Year
0 5 10 15 20 25 30 35 40 45 50 55 60
Millions of Dollars
CUMULATIVE CAPITAL AND ENGINEERING CONSTRUCTION CONTRACTS AS REPORTED BY E.N.R.
Millions of Dollars
Contracts
New capital
1934 total inc. federal
1934
1935
1934 private investment
Private investment 1935
1935 total incl federal
*Federal PWA withdrawals exceeded reallotments
PREVIOUS 4-WEEKS MOVING AVERAGE - CONSTRUCTION CONTRACTS AS REPORTED BY E.N.R.
1934
1935
1933
Jan Feb Mar Apr May June July Aug Sept Oct Nov Dec

Current Construction Unit Prices

Mississippi River Locks 13 and 14

CONSTRUCTION of two locks forming part of the upper Mississippi River canalization program started in August, 1935, with the award of contracts for locks No. 13 and 14 by the U. S. Engineer Office at Rock Island, Ill. Lock 13 is located on the Illinois shore above Clinton, Ia., 40.5 miles upstream from Rock Island; lock 14 is on the Iowa shore below LeClaire and 11 miles upstream from Rock Island. Each lock will have chamber dimensions of 600 ft.x110 ft., with upper and lower guide walls of 517 ft. and 500 ft. respectively. The overall length of lock and guide walls is 1,940 ft. At lock 13 there will also be an auxiliary lock 360 ft. x 114 ft.; a dike 8,700 ft. long connecting with an existing highway by an 850 ft. roadway extension; and a 10,500-ft. channel, 55 ft. wide, to divert Johnson Creek to an outlet downstream from the lock.

The following tabulation lists the quantities for each project, the successful unit bids and the totals of the three low bidders in each case. For lock 13: (A) McCarthy Improvement Co., Davenport, Ia. (contract) $1,999,489; Central Engineering Co., Davenport, Ia., $2,149,900; Siems-Helmers, Inc., St. Paul, Minn., $2,193,310. For lock 14: (B) Central Engineering Co., Davenport, Ia., (contract) $1,186,081; Maxon Construction Co., Dayton, O., $1,193,740; S. A. Healy Co., Chicago, Ill., $1,202,304. Major R. A. Wheeler is District Engineer in charge of both projects.

LOCKS 13 AND 14, MISSISSIPPI RIVER

	Lock 13		Lock 14	
	Quan.	A	Quan.	B
1. Cofferdam—lin.ft.	948	$275.00	1,940	$88.00
2. Clearing—total		6,000.00		
3. Excavation, top soil—cu.yd.	36,000	.30		
4. Excav. common—cu.yd.	205,000	.30	4,000	.55
5. Fill, common—cu.yd.	172,000	.17	102,500	.25
6. Fill, top loam—cu. yd.	7,900	.72		
7. Fill, embank. dike—cu.yd.	246,000	.36		
8. Piles, vert. timber—lin.ft.	235,800	.49		
9. Piles, batter timber—lin.ft.	14,250	1.025		
10. Piles, test, timber—lin.ft.	630	1.03		
11. Piles, steel sheet—sq.ft.	98,200	1.07	4,000	1.35
12. Pile load test—each	5	200.00		
13. Timber, common—M.B.M.	394	57.00		
14. Timber, white oak—M.B.M.	33.6	140.00	18	250.00
15. Stone, derrick—cu.yd.	1,780	4.35		
16. Stone, riprap—cu.yd.	21,500	3.00	285	1.50
17. Gravel, embankment—cu.yd.	9,150	2.03		
18. Gravel, road surf.—cu.yd.	3,950	2.18	1,000	3.00
19. Concrete, Cl. A.—cu.yd.	1,030	21.50	700	18.00
20. Concrete, Cl. B.—cu.yd.	80,000	10.46	54,500	10.37
21. Steel, struct. wall armor—lb.	738,000	.065	456,000	.06
22. Steel struct. miter gate—lb.	765,000	.07	466,000	.096
23. Steel struct. tainter valve—lb.	79,800	.08	79,800	.10
24. Steel struct. misc.—lb.	287,000	.085	233,000	.062
25. Steel struct. chromium—lb.	900	.27	900	.25
26. Steel, reinforcing—lb.	1,295,000	.04	1,200,000	.045
27. Steel, corros. resist.—lb.	10,750	.56	8,300	.44
28. Steel, struct. nickel—lb.	470	.30	305	.20
29. Forgings, steel—lb.	179,000	.16	112,000	.11
30. Forgings, nickel steel—lb.	6,330	.25	5,900	.20
31. Castings, steel grade O—lb.	4,900	.16	3,000	.10
32. Castings, grades 1 to3—lb.	91,400	.13	70,000	.115
33. Castings, nickel steel—lb.	9,350	.17	7,050	.20
34. Castings, iron—lb.	29,300	.08	21,000	.07
35. Bronze—lb.	3,240	.60	2,390	.40
36. Copper—lb.	350	.50	97	1.40
37. Non-ferr. metal,misc —lb	4,100	.28	3,800	.19
38 Pipe, brass, extr. strength, ½ in. —lin. ft.	363	.70	242	.50
39 Pipe, W. I. bl. extr. str. 2 in.—lin.ft.	520	1.00	260	.90
40. Pipe, drain, 10 in.—lin.ft.	870	.80		
41. Pipe, drain, 4 in.—lin.ft.	295	.50		
42. Pipe, corr. galv. 24 in.—lin.ft.	71	3.00		
43. Pipe, corr. galv. 18 in.—lin.ft.	105	1.25		
44. Conduit fiber 4 in.—lin.ft.	135	.30	1,650	.50
45. Conduit, fiber, 3 in.—lin.ft.	49,900	.25	33,000	.35
46. Conduit, fiber, 2 in.—lin. ft.	7,310	.24	6,600	.30
47. Conduit, metal, 2 in.—lin.ft.	870	.60	615	.75
48. Conduit, metal, 1½ in.—lin.ft.	85	.50	75	.60
49. Conduit, metal, 1 in.—lin.ft.	40	.45	50	.50
50. Elect. ground system—total		600.00		450.00
51. Handrail, steelpipe—lin.ft.	630	2.00	2,190	2.00
52. Handrail supports—each	136	1.75		
53. Floor gratings steel—sq.ft.	6,640	1.20	4,650	1.10
54. Rubber seals, mld.—lb.	4,910	1.00	3,200	.50
55. Tile gage—lin.ft.	156	6.75	63	7.00
56. Oper. machines, miter gate—each	4	5,500.00	4	4,850.00
57. Oper. mach. tainter valv.—each	4	4,040.00	4	3,600.00
58. Mitergate recess drain—each	4	20.00	4	35.00
59. Street washers, 2 in.—each	4	26.00		
60. Gate valv. wedge 4 in.—each	2	85.00	2	90.00
61. Record gage housing—each	2	200.00	2	150.00
62. Gas tank recess drain—each	1	15.00	1	35.00
63. Catch basin, complete—each	2	60.00		
64. Curb gutter, roads—lin.ft.	1,270	.98		
65. Manhole, complete—each	1	70.00		
66. Excavation, rock—cu.yd.			78,500	1.88
67. Channeling, rock—sq.ft.			31,500	.72
68. Grouting, 0-10 ft.—lin.ft.			3,000	.45
69. Grouting 0-20 ft.—lin.ft.			2,000	.55
70 Pressure grout, cement—bbl.			750	4.50
71. Pipe, c.i. flanged, 6 in.—lin.ft.			22	2.00
72. Pipe, c.i. flanged, 4 in.—lin.ft.			9	1.50
73. Pipe, bell, spigot, 4 in.—lin.ft.			37	.75
74. Pipe, c.i. 20 in.—lin.ft.			36	4.75
75. Pipe, c.i. 24 in.—lin.ft.			61	6.00
76. Pipe, c.i. 30 in.—lin.ft.			160	8.50
77. Fence—lin.ft.			2,725	.25

Gas Line Relocation, Muskingum Valley

NEW 18- and 20-in. gas lines, approximating 2½ miles of new pipe and 2½ miles of reworked and reconditioned pipe are being laid near the Atwood reservoir for the East Ohio Gas Company. The work is scheduled for 100 days completion and forms part of the Muskingum, Ohio, water control program. The contractor furnishes all labor and material other than for the existing pipe lines, reconditioning of which is included in the contract.

Considerable range existed in the 7 proposals submitted, from the contract low of $134,735.50 to the high of $203,006. The following tabulation lists the quantities and units of the three low bidders. (A) O. V. Arnett, Berea, Ky. (contract), $134,735; (B) Whitney Bros & Co., Charleston, W. Va., $135,019; (C) Coolsact Bros. Co., Dearborn, Mich., $139,334. Capt. A. C. Lieber is District Engr. in charge for the U. S. Engineer Dept.

GAS LINE CHANGES, ATWOOD RESERVOIR

	A	B	C
1. Steel pipe 18-in.—9,800 lin.ft.	$5.25	$4.30	$4.00
2. Welded steel pipe 18-in.—1,000 lin.ft.	5.25	4.45	4.22
3. Steinmiller valve station complete—total	4,250	4,500	8,494
4. Atwood valve station, complete—total	4,950	5,000	9,792
5. Steel pipe, 20-in.—1,850 lin.ft.	5.00	4.80	4.01
6. Welded steel pipe, 20-in.—500 lin.ft.	5.00	5.00	6.43
7. Recondition existing 18-in. pipe—2,450 lin.ft.	2.00	1.40	2.30
8. Recondition existing 20-in. pipe—2,350 lin.ft.	2.25	1.50	2.41
9. Remove, Rework pr. 18-in. pipe—6,830 lin.ft.	1.00	1.00	1.26
10. Remove, Rework pr. 20-in. pipe—6,830 lin.ft.	1.00	1.10	1.26
11. Install, Reworked 18-in. pipe—4,300 lin.ft.	1.50	1.10	.94
12. Install, Reworked 20-in pipe—4,350 lin.ft.	1.50	1.30	.93
13. Steel pipe factory bends, 18-in.—48, each	150.00	210.00	141.05
14. Steel pipe factory bends, 20-in—27, each	170.00	230.00	174.59
15. Steel pipe casing, 24-in.—335 lin.ft.	7.00	7.50	13.52
16. Steel pipe casing, 26-in.—130 lin.ft.	8.00	8.00	16.60
17. River clamps, 18-in.—28, each	10.00	70.00	62.46
18. River clamps, 20-in.—14, each	10.00	76.00	69.66
19. Pipe line, 18-in.—400 lin.ft.	5.50	5.40	4.95
20. Haul removed pipe—2,000 ton miles	.15	.15	.10
21. Pipe line, 20-in.—200 lin.ft.	5.50	6.00	5.47
22. Half river clamps, 18-in., U bolts—132, each	5.00	45.00	29.99
23. Half river clamps, 20-in., U bolts—68, each	6.00	50.00	33.36

Railroad Relocations, Muskingum Valley

RAILROAD relocations made necessary through the Muskingum Valley water conservancy program are under construction since the spring of 1935, bids being taken in July.

LOW BIDDERS, MUSKINGUM VALLEY RAILROADS

I. Wheeling & Lake Erie RR., Dover Reservoir:	
(A) Arundel Corporation, Baltimore, Md. (Contract)	$1,647,717
(B) York Engineering & Construction Co., York, Pa.	1,652,450
(C) Robert J. Dienst, Columbus, Ohio, & W. L. Johnson Const. Co. Hicksville, Ohio.	1,688,419
II. Baltimore & Ohio RR. Bolivar Reservoir:	
(D) Elmer O. Vogt Paving Co., Massilon, Ohio	452,364
(E) Oliver J. Trudeau, Detroit, Mich.	466,495
(F) W. L. Johnson Const. Co., Hicksville, Ohio	492,906
III. Baltimore & Ohio RR., Dover Reservoir:	
(G) Tri-State Engineering Co., Waynesburg, Pa.	127,162
(H) W. L. Johnson Construction Co., Hicksville, Ohio	130,451
(I) Ames Railroad Const. Co., Cleveland, Ohio	133,890

1935, for four more realignments adjoining the Charles Mill, Bolivar and Dover reservoirs. To afford ample unit price comparison, three of the projects ranging in total cost from $127,162 to $1,652,450 are presented with characteristics, unit prices of principal items and totals for the three low bidders in each case tabulated. A considerable portion of each embankment is of 8-in. layered levee construction. Capt. A. C. Lieber, District Engineer, Zanesville, is in charge.

CHARACTERISTICS OF MUSKINGUM VALLEY R.R. RELOCATIONS

	Wheeling & Lake Erie R.R. Dover Reservoir	Baltimore & Ohio R.R. Bolivar Reservoir	Baltimore & Ohio R.R. Dover Reservoir
Low Bid	$1,652,450.00	$452,364.50	$127,162.00
Schedule time	500 days	490 days	270 days
Length	14.6 miles	5.85 miles	2.04 miles (0.2 miles embankment only)
Width of roadway embankment at subgrade	20 ft. plus 6 ft. for ditches, and 14 ft. for sidings	20 ft. plus 6 ft. for ditches, and 13 ft. for sidings	1.3 miles—16 ft. plus 6 ft. for ditches 0.74 miles—20 ft. plus 6 ft. for ditches and 13 ft. for sidings
Base of rail grade above subgrade	2 ft. main track; 1 ft. 7 in. sidings	1 ft. 7 in. main track; 1 ft. 3 in. sidings	1 ft. 3 in. for 1.3 miles; 1 ft. 7 in. for 0.74 miles
Weight of track	110 lb.	100 lb.	100 lb.
Temporary trestles	786.49 ft—25 to 51 ft. high	507 ft.	Approx. 50 ft.
Levee embankment, made up 8-in layers	4,075 ft.	3,930 ft.	Approx. 1,000 ft.
Concrete pile trestles	94.17 ft. dble. track—55 ft. piles 125.42 ft. single track—52 ft. piles		
Materials furnished by R.R. f.o.b. cars	All side track materials, except ties, ballast, bolts, spikes, etc.	All main & side track materials, except ties, ballast, bolts, spikes, etc	All main & side track materials, except ties, ballast, bolts, spikes, etc
Transportation facilities	R.R. parallels relocation; 71 car siding	R.R. parallels relocation; 20 car siding	R.R. parallels relocation; 10 car siding
PWA wage scales (minimum)	Skilled $1.20 Semi-skilled .55 Common .50	Skilled $1.20 Semi-skilled .55 Common .50	Skilled $1.20 Semi-skilled .55 Common .50

UNIT PRICES OF PRINCIPAL ITEMS OF THREE LOWEST BIDDERS ON EACH OF THREE RELOCATIONS

Item	Wheeling & L. E. R.R. Dover Reservoir				Baltimore & Ohio R.R. Bolivar Reservoir				Baltimore & Ohio R.R. Dover Reservoir			
	Quan.	A	B	C	Quan.	D	E	F	Quan.	G	H	I
1. Clear & grub—acre	80	$110.00	$100.00	$100.00	30	$300.00	$70.00	$260.00	12	$100.00	$110.00	$500.00
2. Grade, excavate, unclassified—cu.yd.	1,100,000	.305	.40	.39	600,000	.26	.30	.32	73,500	.35	.40	.47
3. Grade, borrow, unclassified—cu.yd.	190,000	.25	.40	.32	70,000	.24	.35	.26	95,000	.35	.32	.37
4. Load, haul, distribute top soil—cu.yd.	10,000	.30	.50	.40	10,000	.20	.30	.40				
5. Overhaul, over 3,000 ft.—cu.yd.	750,000	.01	.01	.01	350,000	.01	.01	.01	1,000	.02	.04	.03
6. Remove, load on cars, steel spans, timber decks & stringers of temporary trestles—total	2	1,500.00	5,000.00	3,000.00	2	1,000.00	500.00	1,200.00	1	200.00	100.00	300.00
7. Plow levee embankments—acre	10	25.00	5.00	20.00	15	10.00	5.00	20.00				
8. Foundation excavation, general—cu.yd.	16,500	.95	1.00	.80	3,000	1.00	.50	1.00	600	1.00	6.00	1.50
9. Foundation excavation, special—cu.yd.	1,600	4.50	3.00	8.50	950	6.00	2.50	6.00				
10. Concrete, class A—cu.yd. (5.5 bags)	8,500	14.00	14.00	15.00	1,450	14.00	13.00	14.00	600	17.50	16.00	15.00
11. Concrete, class B—cu.yd. (4.5 bags)	4,100	13.00	12.00	14.60	1,900	12.00	12.50	13.50				
12. Drill holes, rock & concrete—lin.ft.	200	.75	.50	.40	100	1.00	.60	2.00	20	1.00	1.00	3.00
13. Furnish, place steel reinforcing—lb.	1,190,000	.05	.04	.0375	170,000	.04	.05	.04	50,000	.04	.044	.04
14. Piles, temporary trestle, 20 to 30 ft.—lin.ft.					7,000	.45	.50	.50				
15. Piles, temporary trestle, 30 to 70 ft.—lin.ft.av.	11,500	.573	.617	.835	500	.60	.70	.60				
16. Timber, temporary trestle—M.B.M.	165	80.00	100.00	80.00	75	100.00	75.00	90.00				
17. Hardware, temporary trestle—lb.	20,000	.06	.08	.08	12,000	.08	.10	.10				
18. Structural steel, furnished in place—lb	375,000	.07	.05	.05	170,000	.055	.05	.048	1,500	.06	.10	.10
19. W. I. hand-rail, 2 in., placed—lin.ft.	450	2.50	2.00	2.00	100	2.00	1.50	2.00				
20. C. I. pipe culvert in place—ton	260	90.00	90.00	80.00	55	70.00	75.00	80.00	80	80.00	80.00	97.00
21. Vitrified pipe drains in place, 6 in.—lin.ft.	300	.80	1.00	.75	1,000	.60	.50	.60				
22. Vitrified pipe drains in place, 12 in.—lin.ft.	1,000	1.20	1.50	1.60	500	1.00	1.00	1.00	300	1.50	.80	.80
23. Vitrified pipe drains in place, 18 in.—lin.ft.	500	2.00	2.00	1.50	300	1.50	1.80	1.50				
24. Corrugated metal pipe, in place, 24 in.—lin.ft.	160	3.90	8.00	6.50					160	3.50	6.00	6.00
25. Metal seepring—total		250.00	150.00	300.00					7	21.00	280.00	175.00
26. Automatic drainage gate, 24 in. pipe—each	1	200.00	100.00	80.00					1	51.50	40.00	70.00
27. Manually operated sluice gate, 6x6 box culvert—each	1	3,000.00	1,030.00	1,000.00	1	650.00	2,000.00	1,200.00				
28. Riprap—cu.yd.	1,500	3.50	3.00	4.00	300	4.00	3.00	4.00	75	4.00	4.00	3.00
29. Completed railroad track, main—lin.ft.	77,000	5.85	5.15	5.58	30,300	3.30	3.25	3.00	9,640	3.00	3.00	2.87
30. Completed railroad side track—lin.ft.	3,500	5.25	5.15	5.00	8,500	2.90	3.00	2.90	933	3.00	3.00	2.57
31. Completed No. 10 turnouts—each	1	1,500.00	1,400.00	1,500.00	8	450.00	300.00	580.00	1	450.00	800.00	500.00
32. Public, private road grade crossings—sq.yd.	700	3.90	3.00	2.00	350	1.80	2.00	3.00	100	3.00	2.00	2.00
33. Grade crossing approach surfacing—sq.yd.	7,000	1.70	1.50	2.00	3,500	1.50	1.00	1.50	700	1.50	1.50	1.50
34. Pump house—total	1	1,300.00	2,000.00	1,500.00	1	2,000.00	900.00	1,600.00				
35. Pumping, elect. control & water treating equipment—total		1,500.00	1,500.00	1,900.00		1,400.00	2,000.00	1,780.00				
36. Steel storage tank, furnish, instal, complete—total	1	3,000.00	6,000.00	5,555.00	1	6,200.00	6,000.00	6,200.00				
37. C. I. discharge line, 6 in.—lin.ft.	1,250	2.30	1.50	.80	200	1.80	2.00	2.40				
38. Station driveway surfacing—sq.yd.	12,500	1.20	.75	1.25	600	1.00	1.00	1.50	1,800	1.50	1.20	2.00
39. Fertilize & seed—acre	15	150.00	150.00	250.00	15	100.00	100.00	150.00	5	200.00	200.00	300.00
40. Move buildings—total	12	2,000.00	2,000.00	2,000.00					1	100.00	200.00	100.00
41. Move & reinstal roadway signs, etc.—total		1,000.00	200.00	2,000.00					3	10.00	60.00	25.00
42. Right-of-way fences, complete—rod.	10,000	1.50	1.50	1.60	3,750	1.65	1.70	1.60	1,000	1.75	1.60	1.75
43. Right-of-way fence gates—each	50	10.00	10.00	13.00	18	8.00	15.00	12.00	12	10.00	10.00	15.00
44. Remove railroad tracks—lin.ft.	118,000	.15	.10	.20	36,000	.10	.12	.16	11,060	.20	.20	.10
45. Remove switch connections—each	38	50.00	25.00	50.00	11	25.00	30.00	50.00	3	100.00	100.00	50.00
46. Load cross ties, switch & bridge ties—each	20,000	.08	.05	.10	5,000	.10	.10	.08	1,000	.15	.20	.06
47. Dismantle remove, load steel bridges—total	6	6,000.00	5,000.00	4,000.00		3,000.00	500.00	2,000.00				
48. Shift tram track—lin.ft.									1,500	.50	.50	.20
49. Well, brick & concrete lined—lin.ft.	58.5	18.83	10.26	23.93	75	22.67	5.00	26.00				
50. Structural steel, salvage credit—total		2,800.00	4,000.00	3,000.00		2,000.00	500.00	1,000.00				